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SECOND SERIES VOL. V, No. 10

# BULLETIN

OF

# THE NEW YORK ACADEMY OF MEDICINE

OCTOBER, 1929

INSTITUTED 1847

PUBLISHED MONTHLY BY
THE NEW YORK ACADEMY OF MEDICINE
Fifth Avenue and 103rd Street
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## 1929

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# THE HISTORY OF DRAINAGE, IRRIGATION, SEWAGE-DISPOSAL AND WATER-SUPPLY

Visitors to Washington will recall Potomac Park and the attractive one-way speedway which encircles Hains Point, a peninsula of made ground over what was once the great eyesore of the District of Columbia, that festering stretch of slimy marsh and bristling cat-tails known as the Potomac Flats. The reclamation of this haunt of frogs and mosquitoes by Army engineers, backed by Congressional appropriations, was carried on at a tempo incredibly slow—in my recollection it was going on all through my boyhood and long thereafter—but it proved to be one of the most important feats of sanitary engineering executed on this continent, albeit with no specific hygienic intention at the start. For, when the late Dr. A. F. A. King propounded his hypothesis of mosquito-transmission of malarial fever to the Washington Academy of Sciences in 1882, with the recommendation that the city be invested with a colossal woven-wire screen as high as the Washington Monument, he was greeted with loud-resounding Homeric laughter, as a genial purveyor of harmless, humorous paradox. Washington, the sleepy Southern town where political history has been so unobtrusively made that Maximilian Harden murmured *"davon kann man träumen,"* the "city of beautiful distances" which will some day be an object lesson to the world in town-planning, was once the "Swamp-poodle" of Mrs. Trollope, Dickens and its even more satirical inhabitants. In the area from the Potomac waterside to Mount Pleasant Heights, the fair city has, even to this day, some

of the climatic traits of an ex-malarial swamp.[1] Small fortunes were made, just after the Civil War, by judicious real-estate investments in mud-puddles, over which most of the residential and business sections of the city were ultimately built. The reclamation of land for parking in the immense area back of the White House, extending far down the Potomac, was, as stated, not primarily done for sanitary reasons, but as part of the Olmsted program of beautifying Washington by way of landscape gardening. In the light of what is known of Greece and Italy as malaria-infested states, let us imagine the possible fate of the National Capitol, now our tenth city in population, if the chances of convection of malaria, were overwhelmingly increased (as in Ronald Ross's calculations) by increased chances of mosquito-breeding. Even through the eighties and the nineties, malaria was rife in the District of Columbia, so much so that women and children were always taking quinine, like the unfortunate people on the banks of the Mississippi, in the illustrations of Mrs. Trollope's book. "Chills and fever" in fact, had much to do with the poor health and sorry physical appearance of Americans all through these earlier days. Since our participation in the World War, Washington has doubled its population up to half a million inhabitants, and the influx of new people, attracted by political motives, chances for social pleasuring and increased opportunities for big business, is still large. It is only in the last few years that the city has been built up to its present expanded population, as suggested by the long, funereal rows of motor-cars which line every available street. There are still some mosquitoes, and, with the history of Camp Wheeler in mind, no one would dream of claiming a rigid causal-nexus between swamps and malaria. As in the earlier cases of Greece and Rome, there could be no malaria, even in a mosquito-ridden population, without the presence or

[1] Colonel Repington observed that the city is "as hot as Cawnpore" in September. The enervating quality of the climate, with its sudden changes, is a matter of common observation among Army people and their families, fresh from the tropics.

introduction of human carriers. The independent variables are the number of susceptibles, the number of Anopheles on hand and the chances of increased mosquito-breeding; the efficient cause is the existence of the disease in the community or its introduction from without. In old Washington, as in Mauritius before 1866, thousands of people were bitten by non-malaria-bearing Anopheles and remained uninfected, but the chances of infection were continually increased by the number of potential carriers (infected patients and Anopheles) on hand. As the city, *viâ* Congressional representation, is made up of people from every state in the Union, new carriers were ever coming in to take government positions or to follow other employments. The city of Manila is still infested with dengue but is now absolutely free from malaria, because there are no human carriers in the community; but a marching command, sent on an ordnance survey from Fort McKinley, into Batangas, brought the disease into the post upon its return, although the carriers were apparently immune in the hinterland, through routine administration of quinine on the march. After the Russian Revolution and famine, malaria was carried (and still exists) as far north as Archangel, in the Arctic Circle.

The history of the reclamation of Potomac Park and Hains Point is the history of all earlier achievements in sanitation *viâ* drainage, *i.e.*, the attainment of a sanitary end without definite sanitary intention. The classical instance is that of Empedocles, who improved the health of Selinus by reclaiming the swamp land thereabouts and the climate and harvests of Agrigentum by blocking a windy rift in a hill.[1] The primary motive in either case was not sanitary but economic, concerning the livelihood and creature-comforts of the inhabitants. The proof of the pudding is the decline of the mosquito-borne fevers wherever urbanization implies drainage, as in Sierra Leone, Lagos, Ismailia, Port Said, Cairo, Khartoum, Havana, Panama, Guayaquil, the Southern states, the Malay States.

[1] Diogenes Laertius, VIII, 51-77.

or the extensive operations now going on in Italy and Greece. In many cases, *e.g.,* in Camp Travis (San Antonio) or the areas around Fort Santiago (Manila), the exasperating bite of Culex, Aedes or Anopheles is usually a sufficient motive for the usual means of mosquito-reduction, *viz.,* choking the course of small streams, filling up pools and puddles, caulking holes and hollows in trees and general oiling of surface waters. To the wary and well-instructed, the annoyance of the bite connotes the possibility of infection. The history of drainage and the filling-in of swamp areas as sanitary measures for the upbuilding of cities is the history of every village, town or large city which has been accidentally or intentionally rendered healthful by devices centering on the economics of carrying on the world's business "as usual," with an eye to pleasurable living and creature comforts. As being of world-wide extent and duration, its interest is geographic rather than historic, more a matter of space than of time. Recital of dates, in connection with facts, would make a meaningless chronology, with an occasional "high-spot," illustrating the general trend of what Sudhoff calls immanent or intuitive sanitation.

There is scarcely an object or structure in any building, area or street which is not somehow related to the vast science of public, domestic, industrial and individual hygiene. Irrigation deserves our attention as basic in all large scale developments of the world's food-supply. The impounding of great bodies of water often subserves, in fact, the triple purpose of food-supply, water-supply and industrial water-power. Herodotus (II, 149) relates that Lake Moeris, in the Fayúm, was filled, as the Nile flooded, and drawn upon, for irrigation purposes, as the river subsided, a kind of precursor of the Assuan and Sennar irrigation dams. The most astounding developments in the past were those of Ceylon and India, where tanks of gigantic length and area were constructed, by means of earthen dams, for agricultural irrigation.

The oldest of the Ceylonese tanks, near Anuradhapura, was opened by King Panduwaasa, the successor of Vijaya, about 504 B. C. The Giant's Tank (Kattucarré) covered an area nearly equal to that of Lake Geneva (223 square miles), with a retaining bund over 15 miles long and 300 feet broad at the base. Its bed is now the site of populous villages. The Kalaweva Tank (459 A. D.) was 40 miles in circumference, with an earthen dam over 12 miles long and a stone spillway, described by Tennent as "one of the most stupendous monuments of misapplied human labor on the island." The Padavil-Colon tank was 12-14 miles wide, with a dam 11 miles long, over 70 feet high and expanding from 30 feet broad (top) to 200 feet at the base, constructed of hewn stones 6-12 feet long, many of them sculptured with elephant's heads and other devices. Tennent estimates that it cost about £1,300,000, enough to build an English railway 120 miles long, occupying 10,000 men over 5 years. In the Madras Presidency, there were over 53,000 such tanks (43,000 in repair in 1900), each with a dam half a mile long, or 30,000 miles of embankment in all, enough to encircle the globe with a girdle 6 feet thick, apart from 300,000 separate masonry sluices and weirs. The revenue in 1900 was about £1,500,000 sterling. The Ponairy tank at Trichinopoly was 60-80 square miles in area, with a dam 30 miles in length. There are 37,000 irrigation tanks in the Mysore District alone, and 2065 had been constructed under British rule in the Mairwara District since 1854. The Persian reservoir of Koh-rud (Ispahan), the artificial lake of Ajmeer or the Hyder tank (Mysore) are of relatively smaller dimensions. Notable here are the irrigation canals constructed under British rule in the Punjab and the Sind, and the Nadrai Aqueduct, 564 miles long (1881-9), with its great aqueduct bridge (1310 feet), spanning the Ganges with 15 arches, the largest in the world.

Comparable with these ancient barrages of Ceylon, in ingenuity and boldness of design if not in extent, are some of the mighty dams of recent years. The earliest of these, after Oriental antiquity, were erected by the Spaniards, who have always been substantial engineers.

The oldest existing dam in Europe is the Almanza in the province of Albacete (erected prior to 1586), which is 67.8 feet high. The Alicante (1579-94), erected in a narrow gorge of the Monegre River by Herreras, the architect of the Escurial, is the highest in Spain (134.5 feet). The Puentes (1785-91), on the Guadalantin River, destroyed by a flood in 1802, was 164 feet high. The Val del Infierno (1785-91), 116.5 feet high, on the same stream, is now filled with sediment. The Villar Dam (1870-78), on the Rio Lozoya, was constructed by the Spanish government to supplement the water-supply of Madrid by storage. The oldest masonry dams in the United States were erected by the Jesuit Mission Fathers, namely the Old Mission Dam (1770) across the San Diego River and the El Molino, East of Los Angeles erected for the Mission San Gabriel a

Old Mission Dam, near San Diego, California (1770)

few years later. The Zola Dam (1843), affording a reservoir for the water-supply of Aix, was designed by the father of the famous novelist. The Furens (1862-6), regarded as a model of correct construction, was erected by the French government to protect St. Etienne from inundation, while the Pas du Riot (1872-8) formed a reservoir for the city supply. The Bousey Dam, near Epinal (1878-81), slid on its foundations (1884) and in spite of subsequent repairs (1889), actually turned turtle on April 27, 1895, with the loss of 150 lives. The highest in France, the arched dam projected over the narrow gorge of the Drac at Sautet, will attain to 444 feet. The Gileppe (1870-75), the most imposing in Belgium, is 154 feet high, 216.5 feet broad at the base and curves up stream on a radius of 1640 feet. The Vyrnwy Dam (1882-9), impounding waters in the mountains of Wales for the Liverpool supply, rises 161 feet from the base (117.75) and has a top length of 1172 feet. In the early nineties, the Bear Valley Dam (1183-4), on the Santa Ana River, California, which curves upstream with a radius of 335 feet, was accounted the "eighth wonder of the world" by reason of the tremendous pressure withstood for 15 years by a shell of such slender dimensions (64′ x 3-13′); while the San Mateo (1887-8) was then regarded as one of the largest in the world (170′ x 25-176′ x 680′). The Tansa (1886-91), forming a reservoir of 5120 acres for the Bombay supply, is 118 feet high and 8800 feet long. The Krishnaraja is said to be 124′ x 8600′. The Assuan, completed December 10, 1902, and irrigating some 2500 square miles of the Nile Valley, is nearly 1¼ mile (6400 feet) long and 113 feet high, while the Sennar (1926) on the Blue Nile, near Makwar, is 9925 feet long and 130 feet high. Imposing in height and length are

the great dams impounding the Croton and Catskill supplies of New York City, viz., the Croton Lake, 1915 (297′x 2168′), the Ashokan, 1915 (252′x 4650′), the Kensico, 1917 (307′x 182′) and the Schoharie, 1925 182′x 2000′). But it is with the growth of hydroelectric engineering that the greater American dams for irrigation and industrial water-power came into being. It is said that some two-thirds of the water-power now in use in the world has been developed since 1910. About this time arose the Shoshone (1910) in Wyoming (328′x 200′), the Roosevelt (1911) on Salt River, Arizona (280′x 1080′), the Keokuk (1913) on the Mississippi (53′x 4360′), to be followed by the Arrow Rock (1915) in Idaho (349′x 1100′), the Elephant Butte (1916) in New Mexico (306′x 1674′), the Pathfinder (1922) in Wyoming (218′x 432′), the Don Pedro (1923) on the Tuolomne River, California (283′x 1040′), the Tieton (1925) on the Yakima River (222′x 905′), the Mormon Flat (1925) on Salt River, Arizona (225′x 664′), the Exchequer (1926) in California (333′x 930′), the Horse Mesa (1927) on Salt River, Arizona (311′x 764′) and the Wilson (Muscle Shoals) on the Tennessee River (142′x 4500′). Among those projected by the Bureau of Reclamations are the Gibson in Montana (195′x 960′), the Owyhee in Oregon (405′x840′) and the Boulder Dam, approved by the President, June 25, 1929, for impounding the surplus flood water of the Colorado River. The O'Shaughnessy Dam in the Yosemite Valley, California (1929) will ultimately attain to 312′x 900′. In height and extent, many of these great structures are awe-inspiring.

Drainage with sanitary intention could not acquire a scientific status until the significance of such discoveries as the malarial plasmodium (Laveran, 1880) the typhoid bacillus (Eberth, 1880), or the cholera bacillus (Koch, 1883) had been well understood. Irrigation, for agricultural purposes, while a phase of food and soil economics, concerns the physician and the sanitarian less than the engineer. When we come to the disposition of excreta, offal and street wastes, we are upon a more difficult terrain.

In the literature of classical antiquity, facetious references to the normal physiological functions, indicated in English vernacular by "smutty words of four letters each," are plentiful enough; but *faex, faeces* (dregs, sediment, impurity) are never used in the sense of *excrementum*, the ordinary Roman term (so common in Kühn's Galen), nor are they discoverable in the mediæval Latinity of Ducange. *Urina* is common enough, as also *latrina*, with which every

well-appointed Roman house of the better classes was eventually provided; but while urination is occasionally depicted on Greek vases, references to the excreta are conspicuous by their absence in the plays, poems and other secular writings of the Greeks and Romans, even from those of intentionally indelicate character. In keeping with this instinctive cleanliness of thought and deed, foot-baths, shower-baths and wash-stands of modern lavatory type were as common to the Greeks as were water-closets and urinals to the Romans. Water-closets of modern pattern have been excavated at Babylon, Nineveh, Knossos (Crete), Tel-el-Amarna (1400 B. C.), Cairo (640 B. C.), Priene and Pompeii. The *Gesolei* at Düsseldorf (1926), exhibited models of multiple arrangements from Puteoli (45 seats in rectangular formation), the bath-rooms of the Roman military station at Timgad (28 seats in ring formation) and the palace of Augustus Caesar at Rome (3 seats). By contrast with the irresponsible shiftlessness of primitive nomadic man in this regard, Greece and Rome possessed, in fact, the essential elements of a "public comfort room," albeit dispersed in space and time. An Athenian ordinance of 320 B. C. inflicts punishment upon any one apprehended for casting offal in the streets. Every well appointed house in Rome had *latrinae* near the kitchen and it was in the *latrinae* of his palace (according to Lampridius) that the Emperor Heliogabalus met his end. Disposal of excreta from the gigantic tenement-flats (*insulae*) of later Rome was, in all probability, effected by piping into the Cloaca Maxima. This device of water-carriage of sewage seems to have occurred to primitive man at a very early period, as an evolution from the ordinary open street-gutter and was obviously an improvement upon exposure to the air, covering with earth, incineration or storage in receptacles. Savages in the hinterland of the Philippines evacuate their excreta into flowing streams, a trait anathema to the ancient Persian, who tabooed urination into rivers and still disposes of his dead by exposure on high

towers,[2] lest the corpses pollute the four sacred elements, earth, water, air and fire. The Egyptian trait of storage was discovered in Manila by an Army file of my acquaintance in the guise of four tall columns of obelisk type, surrounding a fine Spanish mansion he had rented and containing the accumulated human filth of many decades. Here, the remark of the Indian chief about the U. S. Army latrine will bear repetition: "White man must think a lot of filth to build a house around it." One of the horrors of Naples, in fairly recent years, was the frank deposition of excreta near the sidewalk, to be collected every morning by a sort of *vidangeur,* equipped with an ordinary garden hoe and a pannier attached to his back. In striking contrast, are the wonderful Assyro-Babylonian drains, piping sewage from Assur (the oldest city of Assyria) and Babylon, from the temple of Baal at Nippur (2000-1000 B. C.), from the palaces of Tikulti-Ninib (1250 B. C.), of Sargon at Chorsabad (800 B. C.) and of Nimrod at Nineveh (800 B. C.); the Egyptian systems of copper piping of sewage from the great pyramids and temples; the jointed cannon-shaped terra cotta sewer-pipes of the Cretan Palaces at Knossos (3500 B. C.) and Tiryns (1450-1250 B. C.).

Construction of the Cloaca Maxima in Rome (Livy, I, 56) was begun by Tarquinius Priscus (616-578 B. C.), primarily as an underground drain to lower the groundwater level. Only later was it used as a system of conduits for removal of excretal wastes, as the city expanded in size and population, in connection with which, its first

[2] Captain Theodore Bitterman, U. S. Army (Ret.), who visited two Towers of Silence in Bombay in 1924, states that the Parsee (Persian) dead from India are sent to them for disposal. The venerable trees about the twin Towers swarm with patient vultures, greedy to get at their work of scavenging the polluted human flesh. Directly a naked corpse is exposed on the Tower by the Parsee priests, who lift the cloth which covers it, the whir of mighty wings resounds and the dead body is stripped to the bone in a few minutes. The dried skeleton (regarded as clean) is then dropped through a grating into the deep dust at the bottom of the Tower and eventually decomposes. Over a long period of time, the depths, as computed by British officials, have remained nearly constant.

cleansing occurred under the ædileship of Marcus Agrippa (33 B. C.). This great seven-fold system is described by Pliny (xxxvi, 24) as follows:

Cloaca Maxima, Rome. (Etching by Piranesi)

"For this purpose, there are seven rivers made by artificial channels, to flow beneath the city. Rushing onward, like so many impetuous torrents, they are compelled to carry off and sweep away all the sewerage; and swollen as they are by the vast accession of the pluvial waters, they reverberate against the sides and bottom of their channels. Occasionally, too, the Tiber, over-flowing, is thrown backward in its course, and discharges itself by these outlets: obstinate is the contest that ensues within between the meeting tides, but so firm and solid is the masonry, that it is enabled to offer an effectual resistance. Enormous as are the accumulations that are carried along above, the work of the channels never gives way. Houses falling spontaneously to ruins, or levelled to the ground by conflagrations, are continually battering against them; the ground, too, is shaken by earthquakes every now and then; and yet, built as they were in the days of Tarquinius Priscus, seven hundred years ago, these constructions have survived, all but unharmed. We must not omit, too, to mention one remarkable circumstance, and all the more remarkable from the fact, that the most celebrated historians have omitted to mention it. Tarquinius Priscus having commenced the sewers, and set the lower classes to work

upon them, the laboriousness and prolonged duration of the employment became equally an object of dread to them; and the consequence was that suicide was a thing of common occurrence, the citizens adopting this method of escaping their troubles. For this evil, however, the king devised a singular remedy, and one that has never been resorted to, either before that time or since: for he ordered the bodies of all who had been thus guilty of self-destruction, to be fastened to a cross, and left there as a spectacle to their fellow-citizens and a prey to birds and wild beasts. The result was, that that sense of propriety which so peculiarly attaches itself to the Roman name, and which more than once has gained a victory when the battle was all but lost, came to the rescue on this occasion as well; though for this once, the Romans were in reality its dupes, as they forgot that, though they felt shocked at the thoughts of such ignominy while above, they would be quite insensible to any such disgrace when dead. It is said that Tarquinius made these sewers of dimensions sufficiently large to admit of a wagon laden with hay passing along them."

Apart from the great work of Frontinus on the Roman water-supply, the best consecutive treatise on hydrology and mineral waters in antiquity is to be found in Pliny (xxxi, 1-34). The old naturalist's chapters are fascinating in many details regarding the medicinal properties of various waters and the great aqueducts of the Eternal City. Natural drainage areas and watersheds for rainfall over impenetrable soil, springs, shallow wells, clear flowing streams, ponds and lakes were obviously at hand before the advent of the sunken well and transmission by piping. The superiority of flowing over still or stagnant water was known. Not all river waters proved to be equally palatable, and, to this day, deep lakes have remained natural reservoirs of the best water-supply for cities, since they do not commonly freeze over, and so furnish cool water in summer and water relatively warm in winter, at the same time being freer from fauna, flora and micro-organisms. Pliny (xxxi, 1-37) dilates on the healing properties of the mineral springs of Aquitaine, Narbonne, Baiae, the Campagna and the Pyrenees, on waters good for insanity, sterility, abortion, inebriety, lovesickness, waters that dye the hair or improve the voice and so on. He regards the boiling of water for purification as an invention of Nero, but it was already known to Hippocrates (Littré, II, 36) and Aristotle and was em-

ployed in the army of Cyrus (Herodotus, I, 188). The Castalian Spring on Mount Parnassus was sacred to Apollo and the Muses. Pindar (*Ariston men udor*), Horace (*Fons Bandusæ*) and other poets, as well as the cult of Juturna, bespeak the concern of the Greeks and the Romans for purity of water-supply. Romulus chose for the site of Rome "a place abounding Springs" (Cicero).[3]

A fairly complete conspectus of the status of nomadic and pastoral man in the deserts of Asia, with reference to problems of water-supply, drought, drainage, irrigation and inundation, may be pieced out by the simple process of "searching the Scriptures."

"I give waters in the wilderness and rivers in the desert, to give drink to my people, my chosen." Isaiah xliii, 20.

"There went up a mist from the earth and watered the whole face of the ground." Genesis ii, 6.

"And Lot lifted up his eyes and beheld all the plain of Jordan, that it was well watered everywhere." Genesis xiii, 10.

"And when they came to Marah, they could not drink of the waters of Marah, for they were bitter." Exodus xv, 23.

"For the Lord thy God bringeth thee into a good land, a land of brooks of water, of fountains and depths that spring out of valleys and hills." Deuteronomy viii, 7.

"But the land, whither ye go to possess it, is a land of hills and valleys and drinketh water of the rain of heaven." Deuteronomy xi, 11.

"Unstable as water, thou shalt not excel." Genesis xlix, 4.

"For we must needs die, and are as water spilt on the ground, which cannot be gathered up again." II Samuel xiv, 14.

"There shall not be dew nor rain these years." I Kings xvii, 1.

"And thou shalt be like a watered garden, and like a spring of water, whose waters fail not." Isaiah lviii, 11.

"The parched places in the wilderness, in a salt land and not inhabited." Jeremiah xvii, 6.

"The waters wear the stones; thou washest away the things which grow out of the dust of the earth." Job xiv, 19.

[3] The principal of these were the springs of the Camenae (Prophetic Nymphs), the Fons Apollinis, both in the Egerian Valley, and the Fons Juturna, near the Forum. These springs were controlled by special officials, the *magistri et ministri fontis*.

"He bindeth up the waters in his thick clouds; and the cloud is not rent under them." Job xxv, 8.

"My flesh longeth for thee in a dry and thirsty land, where no water is." Psalms lxiii, 1.

"Drink waters out of thine own cistern, and running waters out of thine own well." Proverbs v, 15.

"And the parched ground shall become a pool and the thirsty land springs of water." Isaiah xxxv, 7.

"The rain also filleth the pools." Psalms lxxxiv, 6.

"Stolen waters are sweet." Proverbs ix, 17.

"Blessed are ye that sow beside all waters." Isaiah xxxii, 20.

"When the poor and needy seek water and there is none." Isaiah xli, 17.

"And the nobles have sent their little ones to the waters; they came to the pits and found no waters; they returned with their vessels empty." Jeremiah xiv, 3.

"Behold, waters rise up out of the north, and shall be an overflowing flood, and shall overflow the land." Jeremiah xlvii, 2.

"The waters made him great, the deep set him up on high with her rivers running round about his plants, and sent out her little rivers unto all the trees of the field." Ezekiel xxxi, 4.

"There are wells without water, clouds that are carried with tempest, to whom the mist of darkness is reserved forever." II Peter ii, 17.

"A righteous man falling down before the wicked is as a troubled fountain and a corrupt spring." Proverbs xxv, 26.

"Or ever the silver cord be loosed, or the golden bowl be broken, or the pitcher be broken at the fountain or the wheel broken at the cistern." Ecclesiastes xi, 6.

"For my people have committed two evils; they have forsaken me the fountain of living waters and hewed them out cisterns, broken cisterns, that can hold no water." Jeremiah ii, 13.

"At the end of the conduit of the upper pool, in the highway of the fuller's field." Isaiah vi, 3.

"Now there is at Jerusalem by the sheep market a pool which is called in the Hebrew tongue Bethesda, having five porches." (Discovered 1888.) John v, 2.

And the rest of the acts of Hezekiah and all his might, and how he made a pool and a conduit, and brought water into the city, are they not written in the book of the chronicles of the kings of Judah?" II Kings xx, 20.

The rules in Deuteronomy (XXIII, 9-14) for the policing of a camp contain the germinal idea of the military latrine:

12. Thou shalt have a place also without the camp, whither thou shalt go forth abroad.

13. And thou shalt have a paddle upon thy weapon; and it shall be when thou wilt ease thyself abroad, then shalt dig therewith, and shalt turn back and cover that which cometh from thee.

All the essential modes of husbanding water-supply, from storage of rain-water in jars and cisterns, sinking of wells and guarding of desert springs in the oases, to ultimate piping by conduits, are in the Biblical narratives, and it is reasonable to infer that methods in Assyro-Babylonia and Egypt were substantially the same.

The great Mesopotamian plain was originally reclaimed from an uninhabitable swamp and rendered the most fertile region in the ancient world by irrigation. Of the great network of canals, the three largest, the Nahr Sarsar (Zabzallat), the Kutha and the Ar-Malcha or King's Canals, carried the waters of the Euphrates over to the Tigris above Babylon and the Pallukukatu, watering an immense tract of land parallel with the Euphrates, was probably the "Canal of the Sun God," mentioned in the ancient texts. According to Herodotus (I, 193), wheat from this region gave a 200-300 fold yield and Pliny states that it was cut twice yearly. In the city of Babylon, as Strabo (xvi, I, 5) and Diodorus Siculus (II, 10, 6) relate, water was raised from the Euphrates by means of a screw, and a reservoir has been excavated in the triangular south-east corner of the great inner wall. The water-courses were probably in keeping with the system of gigantic drains, of which models were exhibited at the hygienic expositions at Dresden (1911) and Stuttgart (1926). Similar arrangements for water-supply and sewage-disposal were doubtless evolved in Egypt, but as modern Alexandria stands exactly over the ancient site, now largely under water through subsidence of the coast, extensive excavation is impossible. Palestine, apart from Mount Lebanon and the fertile Mediterranean littoral, is a desert land. The river Jordan, unlike the Nile, is useless for wide-spread irrigation and there are no other flowing streams of consequence; but springs abound everywhere and the whole country is so pitted with the remains of ancient cisterns that walking by night over the fields and hills is sometimes dangerous. The most abundant springs are the sources of the Jordan (at Banias), Tell-el-Kadi and the ancient Virgin's Fountain, the only natural source of water around Jerusalem. Storage of water in the narrow-mouthed, bell-shaped cisterns, hollowed in the rock and lined with cement, was necessitated by the long period of drought (May to November) and the abundant rainfall during April-October. Remains of aqueducts exist at Jericho, Cæsarea and particularly about Jerusalem, which was supplied from the three huge reservoirs known as Solomon's Pools. Water was collected in these pools from Ain-Saleh and other springs and conveyed into the town by siphon-piping through the larger aque-

duct (mainly rock-cut) and a lower winding conduit about 20 miles long. Water was conveyed from the Virgin's Fountain to the Pool of Siloam (or Siloah), an actual reservoir of 58′ x 18′ x 19′ dimensions under the south-east wall, by an underground conduit through the solid rock 1750 feet long, attributed to Solomon. An inscription, discovered by C. Schick, in 1880, reveals the fact that the workmen began to bore at both ends to meet somewhere in the middle. Actually, they had to shaft to locate each other, whence the conduit is 600 feet longer than the direct distance (1110 feet). At present, the main drain of the city discharges into the lower pool of Siloam, converting it into a cess-pit, with seepage into the walls, and the Fountain of the Virgin being also contaminated, the city has virtually no water-supply, by comparison with the past. The Pool of Bethesda was probably north-east of Jerusalem, near the Sheep Gate, where the remains of the five porches mentioned by St. John (V, 2) were excavated in 1888, with a twin pool about 160 yards N. W. of St. Stephen's Gate. The Brook of Kedron was a temporary rill, formed by the heavy winter showers, flowing into the ravine comprising the vale of Jehoshaphat.[4]

In present-day Palestine, arrangements for large scale irrigation and public water supply are almost entirely lacking on account of the survival of traditional methods in a country of peculiar physical conformation and the hazards of experimentation without careful study beforehand. Nearly three fourths of the country is of calcareous formation over hard limestone, in which springs are rare and the mountain freshets (abounding in the rainy season) are unavailable on account of the uneven contour of the terrain. None of the rivers except the Jordan have been utilized for irrigation or water-power, even in the orange groves of the fertile strip along the coast; and, with the exception of the oasis of Jericho, this is also true of the larger springs near the Dead Sea. In consequence, every plantation has its own rectangular well of cement, 3-5 meters wide, with piping for irrigation at the level of the ground water and withdrawal above by the ordinary lever pump or an oil motor. Earlier types of rope-and-wheel wells (the wheel of Ecclesiastes) or capstan wells, run by mules or camels, are disappearing. Practically every house in Jerusalem has a cistern for storage of rain-water, as piped water is too expensive (about 60 cents per cubic meter). The Bibical Solomon's Pools still exist in the shape of three gigantic basins of sunken masonry, 10 meters deep and with a total capacity of 200,000 cubic meters. With a rainfall often averaging 70 millimeters daily in the season, cisterns are easily filled. Dams for irrigation are hardly feasible, as rainwater is rapidly absorbed by the chalky soil.[5]

Similar conditions obtained in ancient Persia and methods of supply were adapted to the contour and geological formation, whereas in Egypt and Assyro-Babylonia, the

[4] For further details, see J. I. Whitty: Proposed Water Supply and Sewerage for Jerusalem, London, 1863.

[5] S. Löwengart, Umschau, Frankf. a. M., 1929, xxx, 271-273.

presence of great rivers, subject to inundation, made for supply by open canals with spacious basins. Before the Roman period, the Phœnicians were the ablest sanitary engineers.

Remarkable were their rock-hewn, subterranean conduits in Cyprus (Citium, Amathus) and the four deep artesian wells near Tyre, piping water 18-20 feet upward into four octagonal towers, whence it was carried by conduits to reservoirs near the shore. Remains of 16 Greek subterranean tunnels, draining Lake Copais in Bœotia, have been found, similar to those described in Polybius and others excavated in Syria and Asia Minor. Natural springs and rock-hewn cisterns were adequate for the smaller Greek communities in the earlier period, but with growth of the population came tunnels, like those made by Eupalinus for the water supply of Megara and of Samos, channeled through a hill supplied to fountains, baths and sewers by piping from a terminal masonry conduit, and ultimately debouching into the harbor (Herodotus III, 60). Athens was supplied by rock-cut conduits passing under the bed of the Ilissus from Hymettus and from Pentelicus, both fusing into a large reservoir outside the city, whence it was conveyed within by a network of underground channels, usually stone-walled, and in one case, large enough for two men to pass through. Another Roman conduit, from Pentelicus, begun by the Emperor Hadrian (117-138 A. D.) and completed by Antonius Pius (138-161 A. D.) is still used and was repaired in 1869. In the Island of Cos, an acqueduct, leading from the Fountain of Hippocrates (Burinna) on Mount Lebanon, has been excavated, consisting of an underground bell-shaped reservoir supplied by the spring, in the side of the hill, ventilated by a shaft from above and leading into a subterranean conduit 114′ long and 6′ wide.

The eleven aqueducts of Rome were among the chief glories of the city and veritable triumphs of Roman sanitary engineering. Nine of these are described in the *De aquaeductibus urbis Romanae* of Sextus Julius Frontinus (35-104 A. D.), a Roman soldier who was city prætor, augur, three times consul (75, 98, 100), Governor of Britain (76-78) and appointed water-commissioner (*curator aquarum*) in 97. He lived under the beneficent reigns of Vespasian, Titus, Domitian, Nerva and Trajan, served in several campaigns and wrote treatises on strategy and the art of war. His book on Roman water-supply has been translated from the only existing MS. in the Monastery at Monte Cassino by Clemens Herschel (Boston, 1899). The nine aqueducts described by Frontinus were:

1. The Aqua Appia, constructed 312 B. C., by the censor, Appius Claudius Caecus, and running 11 miles from the Via Collatina to the Porta Trigemina. The Appia ran from a spring located by Appius and the finder of springs (*Venox*) [6] above Tivoli, in the Campagna valley of the Anoi. It crossed a valley of 300 feet on low arches, proceeding to the *Salinae* (salt-warehouses), whence it was distributed from cisterns by lead-piping.

2. The Anio Vetus (272-269 B. C.), 43 miles in length, constructed by the censor Marcus Curius Dentatus, had its intake out of the Anio River near Tivoli and about two miles from Rome, subdivided into two branches for distribution. The channel (*specus*) was 3.7 feet wide x 8 feet high, built out of massive blocks of masonry (*opus quadratum*) laid in cement (*opus signinum*) and plastered on the inside. About 1100 feet were above ground.

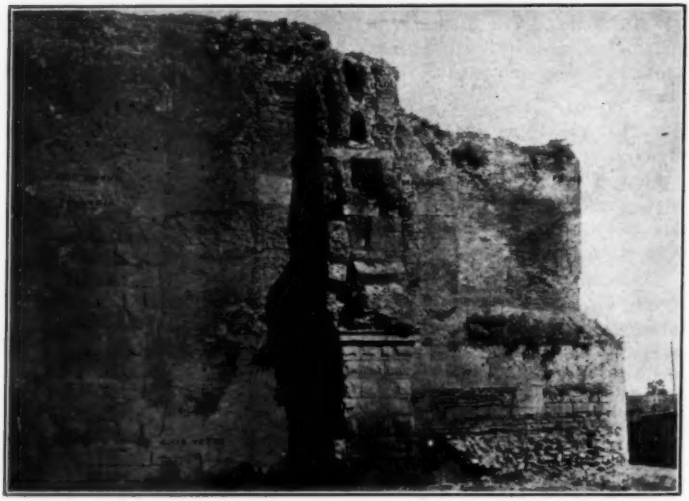
3. The Aqua Marcia (146 B. C.), constructed by the prætor, Quintus Marcius Rex, sprang from the Serena springs on the north bank of the Anio, near Agosta and covered 64¾ miles, 7½ of which were above ground on high arches. In 5 B. C., Augustus Caesar reënforced it by the Aqua Augusta, leading into it from the Rosolina Spring, near Agosta. It was repaired or restored by Titus, Septimus Severus, Caracalla and Diocletian; and was reconstructed in 1869-70 by Pope Pius IX as the Aqua Pia or Marcia Pia. The waters of the Marcian Aqueduct were notable for coolness and purity. The aqueduct itself, the first to run for a long distance on high arches, was celebrated by Pliny, Martial, Statius, Tacitus, Vitruvius and even by Shakespeare (Coriolanus, ii, 3) as one of the architectural glories of Rome. Like its predecessors, the Aqua Marcia was built of rough-hewn "dimension-stone," but soon thereafter the Romans began to be expert in the use of concrete, made from pottery and reënforced by a tough cement made from powdered pottery mixed with lime or volcanic earths. Superimposed upon the arches of the Aqua Marcia for the last 6½ miles of its course above ground was

4. The Aqua Tepula, completed 125 B. C. by the censors Cnaeus Servilius Caepio and L. Cassius Longinus, which arose from volcanic springs on the slopes of the Alban Mountains (the present Sorgenti Preciosa) and reached Rome on the top of the Marcia, a total course of 11 miles. The structure is of reënforced concrete throughout. The water being warm (63° F), and not of particularly good quality, it was after 92 years, ultimately mixed with water from

5. The Aqua Julia (33 B. C.), constructed by Vipsanius Agrippa, which arose from colder springs, two miles away from the Sorgenti Preciosa, and after running for 4½ miles on its own, was superimposed upon the Tepula for the rest of its course (total length 15½ miles). The temperature of the water was thus reduced to 53° F by the mixture at the junction. At the Porta Tiburtina, the Marcia, Tepula and Julia are still recog-

[6] A precursor of the expert with the divining rod.

nizable, piled on top of one another as they cross the gateway. In 272 A. D., the three superimposed arches were incorporated into the Wall of Aurelian and ultimately crowded out by the Aqua Felice (1585). The inscription on the boundary stone reads: AQUA . IULIA . IMP . CAESAR . DIVI . F . AUGUSTUS . EX . S . C . CLVI . PEDES . CCXL. (The Julian Aqueduct, Augustus Caesar, Emperor, son of the deified [Julius] Caesar. By vote of the Senate. Station 156, distance apart 240 feet.)



Entrance and Seven Aqueducts near Porta Maggiore, Rome

6. The Aqua Virgo (33-19 B. C.), also built by Vipsanius Agrippa, arose from a spring on the Via Collatina, in the Campagna valley of the Anio and ran for 14 miles at a low level, entering Rome "under the Pincian hill, to the north of the Piazza di Spagna, with a reservoir near the present Via del Babuino at the end of the Vicolo del Bottino." Being celebrated for its excellent water supply, it was restored to use by Pope Pius V in 1570, and now supplies the ship-fountain in the Piazza di Spagna, ending at the fountain of Trevi.

7. The Aqua Alsietina (10 A. D.), arose from the present Lago di Martignane across the Tiber, 680 feet above sea-level, and ran for 22 miles on a down grade, to supply the water for a marine circus (*naumachia*), for which purpose, as shown by the Ancyrean inscription, it was constructed by Augustus Caesar.

8. The Aqua Claudia (38-52 A. D.), built of dimension stone, with

Aqua Claudia with Anio Novus above (Roman Compagna)

9. The Anio Novus (38-52 A. D.), of brick and concrete on top of it for 7 miles, were begun under Caligula (38 A. D.), and completed under Claudius (52 A. D.) Claudia arose from three springs in the Anio Valley, near the sources of the Marcia, and ran for 45 miles, over 10 of which it rose on arches above ground. Anio Novus got its intake from the Anio River, was 62 miles long, over 9 miles above ground, and acquired an additional intake under Trajan (98-117 A. D.) from one of the three artificial lakes which adorned Nero's Villa above Subiaco. The two aqueducts were hastily constructed and had to be restored by Vespasian (A. D. 70) and Titus (A. D. 81). The ruins of the majestic span of double arches, lauded by Cassiodorus as more beautiful than the Nile, are still one of the features of the Campagna. After Frontinus' time, there came into use

10. The Aqua Trajana (A. D. 109), constructed by Trajan, arising from the present Lago di Bracciano, following nearly the same route as the Alsietina (on the right bank of the Tiber) for over 36½ miles and even higher than Anio Novus. It was restored by Pope Paul V (Aqua Paola) in 1611, but, coming from an inferior intake, is no longer fit for drinking.

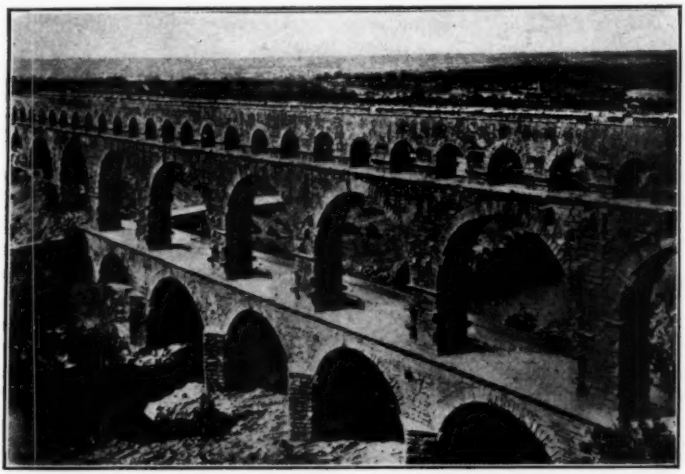
11. The Aqua Alexandrina or Hadriana (A. D. 226), built by Alexander Severus, arose from springs between the Via Praenestina and the Via Labicana, 14 miles from Rome, which now supply its mate, the present subterranean Aqua Felice, constructed by Pope Sixtus V in 1585.

The Romans reared these majestic structures across valleys and rivers solely for the economic reason that lead-piping underground was weak, bronze expensive and the casting of large pipes, withstanding great pressure, be-

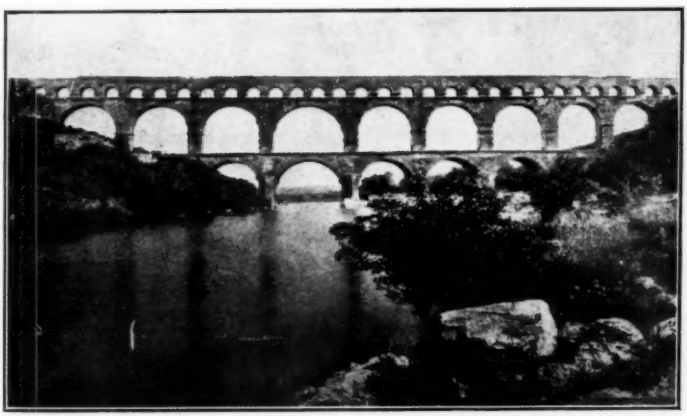
yond their powers of invention. Necessary repairs and detection of leakage were, furthermore, easier in the case of the archways than underground, as evidenced by the system of superimposed double and triple arches in the case of Claudia-Anio-Novus and Marcia-Tepula-Julia respectively. How it was all done is largely a matter of conjecture. Tunnels were either chiselled out of the solid rock by the pick or excavation was effected by pouring cold water or vinegar upon heated rock. The Romans were ignorant of blasting, but they knew that water seeks its level (Pliny xxxi, 57), hence employed siphonage and inverted siphonage in supplying fountains and upper stories, levelling by means of the *Chorobates* (Vitruvius, VIII, 6). They made air-shafts (*lumina*) in the water-courses at intervals of 240 feet, separated out sediment and pebbles by vaulted filter tanks (*piscinae*) delivered the water from terminal reservoirs (*castella*) to bath-tubs and fountains by lead-piping, stop-cocks, wipe-joints and other plumber's fixtures, lifted the huge dimension stones by derricks and effected construction and repair by slave labor and virtual enslavement of soldiery; but they had no means of measuring relations of quantity and velocity of flow in a pipe,[7] so that more than half the water transmitted was lost through unscrupulous tapping and leakage. Herschel estimates a total discharge of 84 million gallons (54 within, 30 without) and a daily consumption of 20 million gallons (38 gallons per person). The cost of construction was high. Pliny (xxvi, 24) estimates the cost of the Claudia and Anio Novus at 55.5 million sestertii (nearly three million dollars) or about $6 per running foot by slave labor (Herschel). Nevertheless, aqueducts swarmed over the entire Roman Empire. Pliny the younger records building two in the year or so of his proconsulate, and 200 or more probably existed throughout the Empire. Apart from Rome, the most important and impressive of the colonial aqueducts in size and height were

[7] The gravitational formula for estimating the velocity of water flowing from an orifice ($V = \sqrt{2gh}$) was first stated simultaneously by John and Daniel Bernouilli in 1738 (Herschel). Daniel Bernouilli was an M. D.

1. The aqueduct-bridge at Nîmes (Nemausus), now known as the Pont du Gard, constructed by Vipsanius Agrippa (under Augustus) and crossing the valley of the Gardon River at a height of 160 feet, one of the most beautiful bridges in the world.



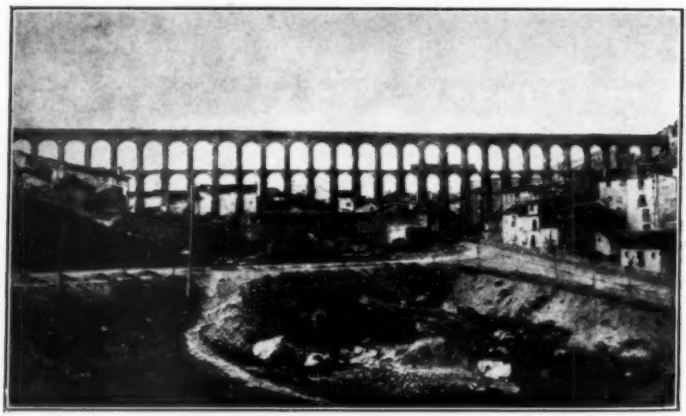
Pont du Gard, Nîmes (Perspective)



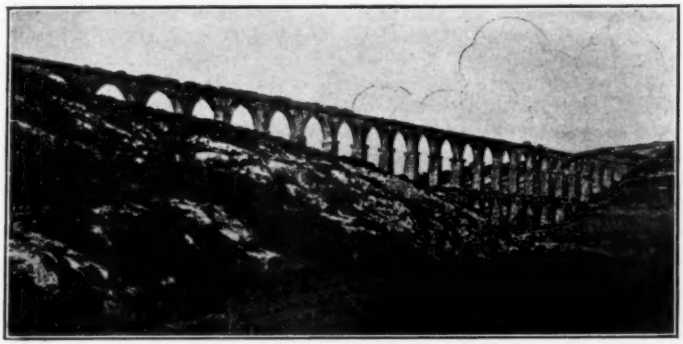
Pont du Gard, Nîmes (Front View)

2. The aqueduct bridges at Segovia, Tarragona (restored 1780-1800) and Merida (Spain), the first consisting of 109 double arches of massive masonry 2400 feet long and 102 feet high.

Roman Aqueduct at Segovia, Spain (109 A. D.) Perspective



Roman Aqueduct at Segovia (Front View)



Roman Aqueduct at Tarragona, Spain

3. The camp aqueduct bridges at Mainz (700 yards long, half resting on nearly 600 pillars) and Luynes.

4. The aqueduct at Jouy-aux-Arches, near Metz, (4th century A. D.)

5. The aqueduct bridges at Antioch (Syria), 700 feet long and 200 feet high, and at Moris, near Mitylene, 500 feet long and 70-80 feet high.

Weber has made an exhaustive study of ancient and mediæval aqueducts of Greek and Roman provenance at Pergamum, Laodicea, Smyrna, Tralles, Aphrodisias, Trapezopolis and other cities in Asia Minor. The most remarkable of the mediæval aqueducts were the present bridge at Spoleto (7th-8th centuries), with 10 Gothic arches, 300 feet high, and a span of 60 feet; and the system of aqueducts supplying Constantinople. These were:

1. The "Crooked Aqueduct," consisting of two branches, one of two tiers of semicircular arches superimposed upon a row of Gothic arches (670 feet long and 106 feet high) and the other of 12 semicircular arches (300 feet long) conveying water collected from springs on Mount Haemus (in a reservoir below Belgrad) into (2.) the Long Aqueduct and (3.) the "Hanging Aqueduct" of Justinian, and finally into a vaulted conduit which ultimately rises above ground as an aqueduct of two arches, meandering thence to the reservoir of Egri Kapu, on the walls of Constantinople, for distribution into the city. The Long Aqueduct, consisting of two tiers of about 50 arches, 2200 feet long, 80 feet high, is evidently of Turkish design and construction.

The Aqueduct of Justinian, 720 feet long, 108 feet high, consists of two tiers of large pointed arches, with span of 55 and 40 feet, supported by huge buttresses broken at different heights by small lateral arches, in all one of the finest aqueducts of the Middle Ages. In addition to these, water was supplied to the northern side of Constantinople by a system

of aqueduct bridges over valleys, with intervening water-towers of obelisk type (*souterasi*), for siphonage and discharge of air. The city is still supplied by the Crooked Aqueduct and the aqueducts of Justinian and Valens, to be stored in various cisterns, one of a capacity 6,571,720 cubic feet. In the Byzantine period, the total supply through the different aqueducts amounted to 400,000 cubic feet *per diem* (Andreossy).

The mediaeval house was usually a small two-storied affair, with few windows and heating only in the bath-room; but the spacious palaces and public buildings were invested at the back by galleries supplied with water-closets. The most remarkable of these were the castles and chapter-houses of the Order of the Teutonic Knights in Eastern Prussia (1229-1525) with their subterranean central heating plants (hypocausts). wells sunk in the premises, water-piping, baths, wash-rooms and tower-latrines (*Dansker-Anlagen*), separated from the main building by rambling galleries, with running water-courses underneath to remove excreta. The most striking of these are at Marienwerder, Thorn, Königsburg and Lockstedt. The Palazzo Davanzati in Florence (1300), recently restored, had separate water-closets attached to each of the spacious dwelling-rooms (3-4) on each of the three stories. Water-closets, and sometimes urinals, also existed in the fortified Castle at Lucera (1233), built by Frederick II, the Castel del Monte in Apulia (1240), the Hohenstauffen palace at Lagopesole (1250), the cloister at Saint Gall and in such riverside castles as those at Bachrach and Oberwesel on the Rhine or Eltz on the Moselle. Sometimes privies or urinals were inset by a blind archway in city walls or city gates, as at Aigues-Mortes (12th century), or in the battlements of fortified castles. The device of disposal by still ponds or running water underneath the privies probably derived from the lake-dwellings of prehistoric man, and is still noticeable in the Philippines. In the smaller towns and the open countryside, domestic arrangements were of the most primitive order, as suggested by the status of Berlin or Naples in the early part of the 19th century or the memoirs of Benvenuto Cellini and Casanova. For a long time, even the sick or the dying lay naked in their beds, with the customary utensil under-

neath, the theme of many droll anecdotes and caricatures. Doctors diagnosed disease at a distance by inspection of the urine, conveyed in flasks of Erlenmeyer shape. Soap and the sweat-bath were introduced by the Teutons, whose proclivity for swimming and the daily warm bath had already been noted by the Roman writers. Communal bathing, in special establishments for the purpose, was developed on an immense scale by the Scandinavians, Teutons and Slavs, and even in private houses, the heated bath-room, or the curtained bath-tub in the summer garden, were found pleasurable enough for a long sojourn, diversified by eating, drinking and playing on musical instruments. In the larger establishments, cupping and venesection were done. The utilization of the public baths for pleasaunce of all kinds has been amusingly depicted by such artists as Dürer, Lucas Cranach, the younger Holbein, Beham, Aldegrever, Grün, and Bock. Commingling of the sexes eventually led to immorality and venereal in-

German Bath-House (Renaissance). Heated from Below

fection, with consequent suppression of these establishments, which had been supported by weekly subscription. The custom extended from the Scandinavian peninsula to Hungary and Switzerland, still exists in Finland and was noticed in Buda Pest by Richard Bright (1814) and latterly by Hopkinson Smith and others. The innumerable paintings of the fair Bathsheba and of Susanna and the Elders afford another pleasant sidelight on the popularity of bathing in these early days. Portable water was delivered to dwelling houses by strolling water-carriers (Cherubini's opera), as in Constantinople or Moscow, from large cans by teamsters, as in present day Manila, or from wells, town-pumps or running springs set in masonry. Washing of the hands in basins after meals or of the feet after a long journey, sometimes as a religious ceremonial, was common custom. From the Biblical episode of Rebecca to the canvasses of Greuze, Fragonard and Anselm Feuerbach, from the scene in Goethe's Faust to the novel of Knut Hamsen, the wayside well has ever been a favorite theme of poet, painter and novelist. The use of mineral waters and baths began with the Romans and, in Germany alone, has expanded to the scale suggested by the *Deutsches Bäderbuch*. Innumerable sanitary ordinances of the mediæval towns, exhumed by Sudhoff and others, indicate the concern of the people about purity of water, the prevention of nuisances, the removal of dead animals and of filth from the public highways and byways. These municipal edicts increase in number toward the middle of the 18th century and for obvious reasons. Sudhoff, in his Dresden Catalogue, lists, in succession, a poetic citation of the 13th century as to the mischances arising from lack of privies, a 14th century memorial of the Fathers of San Lorenzo on Florentine conditions, registrations of privies over the London streets in the *Liber albus Londinensis* (14th century), sidelights from the Decameron of Boccaccio (1344-50), a colored print from Grimani as to lack of facilities for public comfort in 16th century Rome, and a mocking 17th century verse about the urinal in the palace at Versailles. By the 16th century, the water-closet had

disappeared. Sir John Harrington was, in fact, banished from the Court of Queen Elizabeth for publishing his famous treatise on the subject (1596).[8] In the 17th century, domestic privies were few in number and very defective. The night-stool (*chaise percé*) came to be a common substitute. As indicated in the memoirs of the period, its shameless use during public or private audiences by the nobility (*"Quel cul d'ange!"*) expressed a certain fine contempt for decency already manifest among humbler people and the lower animals *sub Jove*. An etching of Frans von Mieris shows emptying of excreta from bedside crockery into the street. Ostade and the younger Teniers revel in sidelights of this kind, as do Swift (even Gray) and the rest of the 18th century poets and novelists. The *Angster*, a special urinal for "anxious" ladies, made of Venetian glass or silver, with a close-fitting orifice emptying by four tubes within, was constructed with a "reverse English" on the humorous implication conveyed in the "bubble-bottles" (for port and claret) of the 18th century. One was to be noiseless, the other noisy. Privy closets or urinals masqueraded as cabinets, commodes, cupboards or public monuments, even at the Place de la Concorde. The introduction of the clyster was occasion for more fun, particularly in Molière and all the paintings and etchings of the 18th century. And so it goes, from a certain humorous custom of the Roman ladies down to Chic Sale's clever satire, "The Specialist" (St. Louis, 1929), which ponders such weighty professional problems as the prospective lifetime of a Sears Robuck catalogue in a well-appointed country privy. We may dismiss this phase of the subject with the jovial gesture of the general in the *Walzertraum*, as he disposes of the reports of his adjutants: *"Es hat mich viel gefreut: es war sehr schön."*

[8] Harington. The Metamorphoses of Ajax. London, 1596. Harington (translator of the *Regemen Sanitatis*) was forbidden the court "till he had grown sober," because the Queen suspected an innuendo against the Earl of Leicester. A "jakes" (Ajax) was a privy and a jakes-farmer a cleaner of privies.

The first of the mediæval cities to possess a public plant for the flotation and piping of sewage was Bünzlau, Silesia (1543), which at this time, also possessed a sewage farm and public water-works. City excreta were usually pumped from cesspools or gutters and removed in casks or wheeled tanks, to be used as manure or deposited outside the town. The Dresden Catalogue lists a chalk-drawing of a court-yard at Salzburg, still existing, with evacuation pipes leading directly into the cess-pool, to the disgust of passers by on the terrace above; an oil-painting of 1609, showing the public discomfort from open gutters in Dresden; a plan for a collective basin for excreta in the city wall at Stuttgart (1630) and a copper-plate of G. Schreiber, showing a gutter for deposition of sewage around the market-place at Leipzig (1712). Arrangements for water-supply in the smaller cities were equally backward, by comparison with the Roman. Views of the city wells, town-pumps and of the water-works at Augsburg (1540), Rostock (1584) and other places, appear in many of the paintings, engravings and etchings of the 17th-18th centuries. As to the difficulties experienced through the centuries in acquiring a suitable water-supply and its filtration for the larger cities, the most instructive example from the viewpoint of sanitation is that of Hamburg,[9] which has now the largest surface plant in continental Europe.

Hamburg was founded in the 9th century and obtained its water originally from the Elbe and Alster basin by means of buckets and later by pumps, except in the marshy districts, where the supply was too brackish. In the 14th century, water was piped through hollow logs from neighboring wells on elevated sites to subterranean cisterns in the lower part of the town. Of these meadow-spring conduit systems, four survived into the 19th century viz., the Catherine well-system (1370-1871), supplying 60 cisterns around the Catherine Church from springs in the Altona district and the St. Pauli suburb, combined, in 1534, with an English system; the Rödings-Market and Deichstrasse systems (1430) running from sources near St. Pauli to supply some 59 wells, among them the Rathaus; and the Dammthor system (1537), rising near the present Rope-walk and replaced in succession, by a spring near the Grindelhof (1622) and (1860) by another near

[9] G. Nachtigall: Techn. Gemeindebl., Berl., 1925-6, XXVIII, 18; 39; 1929, XXXII, 104.

the Johnsallee, to supply the Bourse and 42 other places. The companies running these systems still existed in the nineties. The Alster Basin is separated by two dams, and on the upper dam, the first water-works was erected in 1531, another, on the lower dam, in 1535, and a third, on the upper dam, in 1620. This system supplied 460 premises, but was obliterated by the great fire of 1842. Meanwhile, the first water-system from the Elbe, near the present landing bridge at St. Pauli, was concessioned in 1807 but, being interrupted by the French occupation, was completed by G. E. Bieber in 1822. Up to 1832, the water was pumped by horses, then by steam, up to a reservoir on the height near Wietzel's Hotel, to supply the new town, the suburb of St. Pauli and vicinity. In 1852, the Bieber system was taken over by the city government. The second Elbe system was built by Edward James Smith on the Grassbrook in 1843, was taken over by the state in 1851 and operated until 1871, when it was displaced by the Hanover Depot. An earlier system built by Smith at the Alster Gate in 1833, with attempted pebble filtration, was destroyed in the fire of 1842. The feeble pressure in the three Alster systems was only sufficient to supply the lower stories of houses, the wooden pipes were leaky, the flow was intermittent and irregular, the water frequently contaminated by refuse from building operations along the Alster and, being shut off at night to supply the corn-mills, afforded little protection in the fire of 1842, which destroyed one fifth of the city. The establishment of an adequate municipal supply, run by the city, now became essential, was approved by the council and citizens on June 26, 1844, and put into effect in 1845, combining the old systems of piping with steam propulsion. In October, 1848, the first clear water reached the city from the new pumping works at Rothenburg Place and was opened for regular supply to houses on January 4, 1849. This, the first central water-supply to any German city, was the work of William Lindley. The water ran from the Elbe at flood to three large tanks, for self-purification and was then pumped into a water-tower, 63 meters high, for distribution. From 1871, when the Smith system was broken up, this supplied the whole town with Elbe water, then highly popular with ships sailing on long voyages. It was sometimes contaminated by clay (from inundation) and fauna, but this was also true of London, Paris, Berlin and other cities. The first sand filter, in fact, was that constructed by J. Simpson (1829) for the Chelsea Water-Works (London). In 1857, Lindley planned a sand filter for the Hamburg supply, but the project was dropped through lack of funds in a commercial crisis. Revived in 1871-3 by Medical Inspector Kraus, it was again opposed by the agitation of grafting promoters, who wanted to sell individual filters to house-holders. A third project for a central filter was again defeated by the dilemma of choice between water from the Elbe, the Holstein lakes or sources in the Harz and Teutoburg forests. It was not until 1890 that moneys were appropriated and the filter plant itself, immediately begun, was not slated for completion until 1894. But the cholera epidemic of 1892, which smote Hamburg severely, proved a timely driving

force. During 1831-92, Hamburg had been exposed to cholera 23 times and the example of nearby Altona, which escaped the epidemic of 1892 by previous installation of a filter-plant, afforded an object-lesson. The work was sped by intensive coöperation on all sides and on May 27, 1893, Hamburg was supplied with pure, filtered water, which has stood the test to date. This Elbe system, supplied at Billwarder Island and filtered at Kalterhofe, is the largest surface system on the continent. In 1905, the first underground water system was laid at Billbrook and with the installation of the underground system at Curslack in 1928 (114,000 cubic meters daily), the use of Elbe water was virtually excluded. The cost of the total Hamburg supply, including the Elbe, Billbrook and Curslack systems, the pumping works at Rothenburg Place, the piping, filter-plants and reservoirs, is estimated at about 70 million marks (17½ million dollars). The annual consumption is about 62 million cubic meters (170,000 daily or 152 liters per head *per diem*).

This history is fairly typical of the ups and downs incident to the acquisition of the filtered supplies of pure water with which most of the going, or up-and-coming, cities of the world are now provided.

The history of the London water supply [10] suggests the long periods in which a fairly good supply may suffice for a slowly growing population and the coöperative effort necessary to administrate and provide for a population expanding toward eight millions.

Prior to 1582, the citizens of London obtained their water precisely as did the Hamburgers, by simple bucketing from the Thames or from such shallow wells or springs as Holywell, Clerkenwell or St. Clement's Well, "when on a summer's evening they are disposed to take an airing" (Fitz Stephen). In 1236, Henry III authorized Gilbert Sanford to convey water from Tyburn to London by lead-piping, and these conduit heads were frequently visited in state by the Lord Mayor and other dignitaries, when hunting. In 1582, Peter Morrys, a Dutch engineer, submitted a plan for pumping Thames water to a height for distribution, by means of "forciers" (tidal water-wheels) to be set in certain of the 19 arches of the old London Bridge, a system destined to be the means of the London supply for 240 years (1582-1822). The Lord Mayor "and a goodly companie" saw Morrys throw water over St. Magnus steeple and forthwith granted him a lease of the first arch for 500 years at 10s per annum, with a subsequent lease of the second arch on the same terms in 1584. A third arch was leased to Morrys' grandson in 1701, a fourth to his company in 1761,

[10] Col. Sir F. Bolton: London Water Supply. New ed., by P. O. Scratchley. London, 1888.

and a fifth (on the Southwark side) in 1767. The closure of the archways by these ponderous wheel-works, with the further obstruction by piles around the piers, so dammed the tide at flow, that at ebb, it made for dangerous rapids and eddies, the subject of frequent complaint by the wharfingers and lightermen, who had to shoot them. The wheel water works supplied four million gallons daily, distributed to the city by ten separate sets of main pipes. In 1822, the old London Bridge and the water-works were demolished by Act of Parliament. Meanwhile, there had come into being no less than eight Metropolitan Water Companies, eventually consolidated by the Metropolis Water Act of 1871, viz.:

1. The New River Company, started April 21, 1609, under Parliamentary authorization (Acts of 1605-6), partly financed by Sir Hugh Myddleton, and inaugurated on September 29, 1613, by James I, who reimbursed Myddleton to the extent of half the cost of construction (1612-16). This is supplied by Chadwell spring, the River Lee near Ware, and 13 chalk wells in the Lee Valley. The channel, originally 40 miles long, was completed in five years (1609-13) and affords an unlimited supply. The inauguration (entrance of the water) on Michaelmas Day, 1613, was the occasion of great festivities.

2. The East London Water-Works established by an Act of 1807, authorizing the purchase of the Shadwell Waterworks Company, (1669, authorized 1691), and the West Ham Waterworks (1747) from the London Dock Company. This company supplies East London, Stratford, Bow and vicinity from the River Lee at Chingford, by a settling reservoir at old Ford (11 acres) and a service reservoir, with pumping machinery (The Twins) at East End. The supply, which also comes from the Thames at Sunbury and from chalk wells at Walthamsthow and Chingford, is limited to 10 million gallons daily (Act of 1867).

3. The Chelsea Waterworks Company, chartered (1723) and warranted (1726-7) under George I, originally took water from the Thames at Chelsea (North Bank), with filter-beds (1829), which were moved up the river to Surbiton (1852-6), to avoid tidal contamination. The present intake is at West Molesey (South Bank), with 7 filter-beds at Surbiton and 3 service reservoirs at Putney Heath. The supply is 22 million gallons daily.

4. The Southwark (1771-1822) and Vauxhall (1804) Companies, amalgamated October, 1845, supplied South London from the Thames above Hampton, whence it is pumped to the filter-beds (1855) and reservoir (1869-70) at Battersea, with additional works at Peckham (1871), a high service reservoir at Forest Hill (1886) and a 42 inch main from Hampton to Nunhead. The supply is 24½ million gallons daily.

5. The Lambeth Company was established by Act of 1785, originally at Ditton (Belvedere Road), present intake being at Molesey (1847), with pumping station and filter beds at Ditton (1848) and covered reservoirs at Streatham (1832), Ditton (1848), Rock Hill (1854-5), Selhurst (1859-61), Coombe, Kingston Hill (1863) and Norwood (1876-7). The supply (to the Lambeth District) is 24½ million gallons daily.

6. The Grand Junction Waterworks Company (1811), originally authorized as the Grand Junction Canal Company (1798), supplied part of West London from a station at Paddington (1798), subsequently moved up the river above Kew Bridge (1835) and now comprises pumping stations, filter beds, subsidence reservoirs and covered storage reservoirs at Hampton, Kew Bridge, Campden Hill (Kensington), Shoot-up Hill (Kilburn) and Mount Park (Ealing). The present supply is 24½ million gallons daily.

7. The West Middlesex Waterworks Company was incorporated under George III (1806), with intake above the other works at Hampton and four subsidence reservoirs at Barnes, passing under the river to a pumping station and filter beds at Hammersmith to be distributed to covered reservoirs at Campden Hill, Barrow Hull and Kidderpore. The daily supply is 24½ million gallons.

8. The Kent Waterworks was incorporated by Act of 1809, authorizing purchase of the Ravensbourne Waterworks (1701), is supplied from chalk wells near Grayford and Deptford, with pumping stations at these and four other places and 12 covered reservoirs. As the Company ceased to take water from the River at Ravensbourne in 1862, there is no need of filtration of the clear, pure well water. The average daily supply (1888) was 11,039,412 gallons.

As most of this vast bulk of water comes from the tidal reaches of the Thames, agitation for filtration began early, notably in the "Dolphin" (1827), which pointed out that the filth in the water was swallowed but seldom smelt or tasted. When the cess-pool system was abolished by the Health of Towns Commission (1845), the new system of sewers gradually discharged into the Thames. The cholera epidemics of 1845 and 1849 led to the Metropolis Water Act (1852), making it illegal to take Thames water for domestic use below Teddington Lock. In consequence, all the eight companies were constrained to move their works up the river and to roof in or otherwise cover their distribution reservoirs. Meanwhile, administration of the eight companies was divided and decentralized by the fact that the London County Council exerted authority over only one-third of "Water London," an area of 620 square miles, extending from Ware (Hertfordshire) to Sevenoaks (Kent), Ealing and Sunbury (Middlesex). On recommendation of the Royal Commissions of 1893, large additional storage reservoirs were constructed jointly at Staines (Middlesex) by the New River, West Middlesex and Grand Junction Companies. In 1902, the Metropolis Water Act created the Metropolitan Water Board, authorized to purchase and manage the eight companies, which went into effect on June 24, 1904. In June, 1925, the great Queen Mary Reservoir at Littleton, with a surface area of 723 acres and a capacity of 6,750 million gallons, was opened by King George. In 1916, the Board decided to save coal by chlorinating the water, which then flows by gravity down the Staines Aqueduct in lieu of pumping into the reservoir. It is estimated that the

average daily London consumption (36 gallons per head) would empty a tank as large as Trafalgar Square (2½ acres) and as high as Nelson's column ½ times daily. In other words, the average daily consumption for the population of 1921 (7,480,201) was nearly 270 million gallons.

Following the great fire of 1842, the present sewerage system of Hamburg was begun by William Lindley, the creator of its centric water supply (1845-9). In England, the example set by this installation led to the appointment of the Health of Towns Commission (1843), which rendered two reports (1844-5) revealing the evils resulting from accumulation of filth in cities. While views at this time were inspired by the pythogenic theory of Chadwick and Murchison, that disease arises *de novo* from decomposing filth, the theory was sufficiently correct in its bearings to bring about important results. For while cleanliness may not always connote abolition of communicable diseases, sanitation does connote cleanliness. In 1847, it became obligatory to discharge all sewage into the London drains, which hitherto had received only kitchen wastes. The present sewer system, begun in 1849, was continued by the Metropolitan Board of Works (1856-88) from plans by Sir James Bazalguette (1859-75) and was completed by the London County Council (288 miles). The water carriage system (*sewage-disposal by dilution*) shifted the problem "from the individual to the community" (Winslow). The natural outlet was the nearest body of water and whether for riverside, lakeside or seaside disposal, the system worked as long as the volume of sewage was not too great for rapid dilution and the process of self-purification (oxidation of organic matter) by micro-organisms, which is slow in running water of any kind. For the subjoined account of the six experimental methods employed before the advent of the activated sludge process, I am entirely indebted to the admirable monograph of Winslow and Phelps. (1906).[11]

[11] C.-E. A. Winslow & E. B. Phelps: Dept. Interior, U. S. Geol. Survey. Water-Supply and Irrigation Papers, No. 185, Washington, 1906. For later developments, see C. Imhoff: Fortschritte der Abrwasserreinigung, Berlin, 1925. For the sewerage systems of various towns, see Rep. Metrop. Sewer Commission, N. Y., 1914, 436-481.

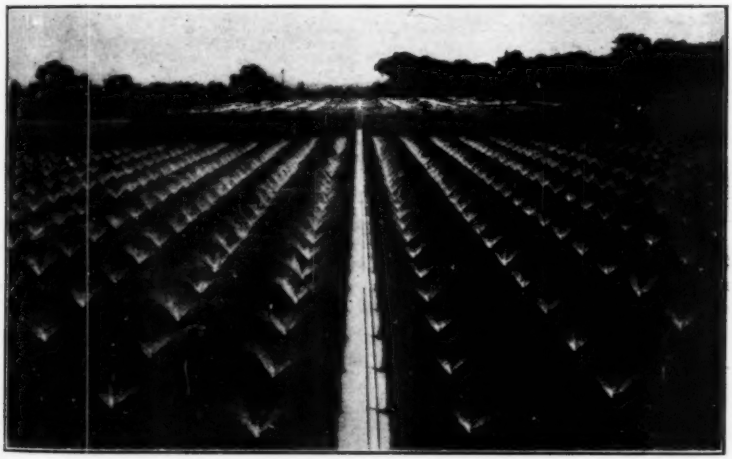
In 1857, the Sewage of Towns Commission (1857) rendered three reports on the best ways and means of distribution (1858-65), stressing the advantages of sewage farming at Milan. These were followed by the six reports (1870-74) of the Rivers Pollution Commission (1868). The net result of these and subsequent investigations was to the effect that a stream is not likely to purify more than 1/50 of its volume of sewage (Winslow), that a stream contaminated with 1/20 its volume of sewage and flowing at the rate of a mile an hour, will have to flow 168 miles in order to purify 2/3 of its sewage, that purification will be more rapid in sluggish streams by virtue of sedimentation and that the best way out is to purify town sewage by farming it on land. Progress in sewage disposal by *broad irrigation* was rapid. In England, sewage farms were established at Croydon (1861), Aldershot (1869), South Norwood (1864), Rugby (1867), Altrincham (1870), Nothingham (1880), Leicester (1891) and Cambridge (1895). The first in Germany was outside Danzig (1300 acres), and was managed by Alexander Aird for 32 years (1869-1901). Following the installation of the Paris sewers by F.-F.-E. Belgrand (1854-56) farms were established at Gennevilliers, Achères, the forest of Saint-Germain and elsewhere (13,338 acres) by Mille, Buffet and Durand-Claye (1866-73). These are used for pasturage and raising table vegetables. The Berlin sewers were constructed by *Baurat* James Hobrecht (1873-83) and the first sewage farm was started at Osdorf (1876), in consequence of the exhaustive reports of Virchow (1868-73). Three other areas were subsequently utilized at Falkenburg (1879), Grossbeeren and Malchow (1882). These farms (22,881 acres) are now the largest in the world, the crops being chiefly timothy and rye-grass. The first sewage farm to be established in the United States was at Cheyenne, Wyoming (1883), which was followed by many others in the Western deserts, where "the manurial value of sewage is reënforced by its water-value" (Winslow). The largest are near Los Angeles and Salt Lake City. The success of the Los Angeles experiment caused a boom in real-estate values (from $2.50 to $25.00 an acre), with such an increase in the population that the sewage became a nuisance and had to be diverted elsewhere. In England, on the other hand, it was found that while sewage farming affords an astonishing yield in some seasons and always covers overhead expenses, it never showed profit as interest on the original investment. In our Eastern states, it is out of the question by reason of the high cost and poor quality of the land and the heavy spring and autumnal rains which defeat its objects. As the population of large cities increased, the problem of pollution became momentous, even with seaside or lakeside towns. Chicago drank its own sewage before the opening of the New Drainage Canal (1892-1900) and even later. Evacuation into the sea became a serious nuisance to Boston as early as 1876. Dibdin estimated that 200 tons of oxygen are necessary to purify the Thamas between Teddington (the terminus of London water-supply) and Southbend (1904). In 1884, a third Metropolitan Sewage Commission (appointed 1882) reported that chemical treatment of London sewage was essential for the Thames, while

in Massachusetts, the reports of William Ripley Nichols and other experts (1881-85) led to the foundation of the Lawrence Experiment Station (1886), with the establishment of purification plants in 23 cities during the next decade. During 1856-76, no less than 416 processes for *chemical precipitation* of sewage had been patented in England. Exhaustive studies of W. J. Dibdin showed that lime and iron salts are the best agents. Following the recommendations of 1884, chemical precipitation works were constructed (1865), at the two outfalls for sewage north of the Thames (Barking Creek) and the south-side (Crossness) and treatment with lime and ferrous sulphate became the rule for the next ten years. By 1895, when Millbury (Mass.), brought suit against the city of Worcester for nuisances resulting from sewage disposal, chemical precipitation became discredited, through its expensive character, the difficulty in disposal of the worthless sludge and the imperfect purification of the effluent. Meanwhile, a third method had come into vogue, viz., purification by *intermittent filtration through sand*, which again turns upon nitrification and ultimate oxidation by bacteria. This theory of *bacterial purification* was first stated and demonstrated in Germany, put to practical application in England, and its chemical nature elucidated in Massachusetts. In 1865, Alexander Mueller expounded purification as a digestive process carried out by animal and vegetable micro-organisms,[12] and subsequently patented a process in which yeast-like organisms were to be used (1878). That the organisms in question are bacteria was first shown by Schloesing and Müntz (1877). The practical advantages of slow, intermittent downward filtration through coarse gravel were demonstrated by Sir Edward Frankland (1870), who perceived the chemical nature of the process (oxidation to $H_2O$, $CO_2$ and nitrates) and likened it to the cycles in respiration, but overlooked the rôle of bacteria. Frankland's principle of a resting (aërating) period between applications of sewage was successfully demonstrated in an intermittent sand filter constructed by Bailey-Denton (1871) at Merthyr Tydvil (Wales), with an eye to making broad irrigation more intensive and remunerative for agricultural purposes. In 1887, Mills, Drown, Sedgwick and Haven, at the Lawrence Experiment Station, demonstrated that the nitrification of sewage by intermittent filtration is a process of oxidation by bacteria, the oxygen being supplied in the resting periods and the porous soil serving as a *point d'appui* for the bacteria. The nitrifying bacteria were isolated in 1890 by Winogradsky in France and E. O. Jordan at Lawrence, where Hazen (1891) showed the relatively long life of intermittent filters, if the dry cake be steadily raked and scraped off the surface of the beds. Intermittent filtration was rapidly established at Framingham (1889), Marlboro (1890), Pittsfield (1890), Gardner (1891), West-

[12] Aristotle (*Historia animalium*, V, 8) was the first to associate the changes in color of the slime of wells with the development of "ascarid" (*Chironomus*) larvæ, but he wrongly reasoned that the larvæ came from the mud and the *Culex* mosquito (*empis*) from the larvæ. A. Thienemann: *Festschr. d. Versamml deutsch. Naturf. u. Aerzte, Münster*, 1912, 175-180.

boro (1891) and other Massachusetts towns. Its success turns upon availability of sandy (porous soil) and minimum sedimentation *via* application of weak sewage. The fourth method of sewage treatment, anaërobic putrefaction in closed *"septic tanks"* already existed *in posse* in cesspools, the *fosses fixées and fosses sèches of the* French and the *vidange automatique* or water-sealed tank of Mouras (1860), patented in 1882. Sewage tanks of this type were constructed by Scott-Moncrief, at Ashtead, England (1891), and by C. N. Talbot at Urbana, Illinois (1894) but anaërobic purification was first made viable by Donald Cameron, who installed the first successful "septic tank" at Exeter, England (1895). It soon became apparent that closure of the tank is not essential, since the chemical reactions involved (sedimentation and subsequent fermentation of solids) are obtainable by slow passage through open tanks. The process is not strictly anaërobic and accumulation of sludge is variable in different filters. Septic tanks seem most successful in small towns or institutions where sandy areas for intermittent filtration are not available, e.g., in the Middle West. The success of these processes turns, therefore, upon local conditions. For this reason, W. J. Dibdin began to experiment on the possibility of a higher rate of filtration through coarser material, at the Barking outfall of the London sewage (1892). The material selected was coke breeze, and as the bed was no longer a filter plant but an oxidizing machine, it became necessary to secure filtration by making the beds water-tight. These so-called *"contact beds"* had their day at the beginning of the 20th century and the results were again variable. Zahn, at Charlottenburg, showed that brick, slag, coal, coke and gravel gave the best results, in the order named. Thumm, at Hamburg, showed that purification is increased by the use of material containing one per cent of iron (1902). Filters made of friable stuff lose their capacity. Due to clogging with solid material, contact beds retain their capacity better with septic effluent than with crude sewage, yet the chemical efficiency of the filter appears to increase with loss of capacity, i.e., with clogging. It was shown by Dunbar and Thumm at Hamburg (1902) that contact filtration is an alternation of aerobic and anerobic processes, starting with the settlement of solids in the sewage on to the surface of the brick or coke filter, with the absorption of the soluble constituents by the colloidal film of bacterial jelly covering these elements of the filter. During the aerobic (aeration) phase, the bacteria set up the ordinary nitrification of the intermittent filter, then the filter completes the liquefying process (hydrolysis) of the septic tank, reducing the nitrates to nitrites, with subsequent decomposition of the latter and liberation of free nitrogen. The "enharmonic" relation of the aerobes and anaerobes is puzzling, whence Winslow defines contact purification as chemically ideal but bacteriologically unsound. The method is evidently an intermediate, experimental phase in the advancement of knowledge, for English opinion (Dibdin, 1903) is to the effect that preliminary treatment in the septic tank will prevent loss of capacity in the contact beds through choking with extraneous material.

Simultaneously with contact treatment, there was evolved a sixth method of purification by *continuous trickling* over large pebbles or similar coarse material, affording abundant aeration through the large interspaces. This process was already implicit in certain experiments with coarse gravel made by Mills (1890) and Hazen (1892) at the Lawrence Station, by Lowcock at Malvern (1894) and in G. E. Waring's device of purification over coke or broken stone by forced oxidation from below (1891-94); but purification by trickling with natural aeration was first described by F. W. Stoddart (1893), who exhibited a model of his method before the British Medical Association in 1894 and established the first working filter of this kind at Horfield (1899). The method was further developed by Corbett at Salford (1893), Ducat at Hendon (1897) and Scott-Moncrief at Ashstead (1898). Here the aerobic condition is constant, aeration being often five times the volume of sewage, so that nitrification seems to increase with the depth of the filter; but even distribution of the sewage is a difficulty which has necessitated such devices as tipping buckets, perforated pipes, sprays and sprinklers. As these methods of rapid puri-



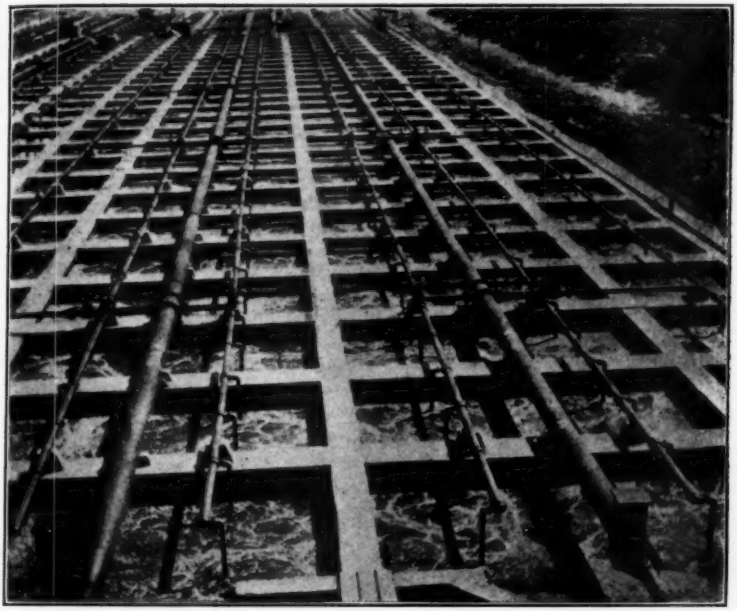
Trickling Filters, with Imhoff Tanks in Background (Columbus, Ohio)

fication came into play, they gradually displaced chemical precipitation. Through the experiments of Dibdin at London and Sutton (1892-6), of Cameron at Exeter (1896), of Latham, Frankland and Perkins at Manchester (1898-9), of Hewson, Harington and Harding at Leeds (1897-1905), most of the other large English cities were strongly in favor of septic tanks with double contact beds or trickling filters; but with such

complex rules for operation that a fourth Royal Sewage Commission was appointed in 1898, with a view to simplification. Four sets of reports (1901-4) authorized the Local Government Board to substitute these methods in place of broad irrigation, wherever practicable. By 1904, Manchester, Sutton, Exeter, Yeovil, Barrhead, Oldham and Burnley were using septic tanks and contact filters, while trickling filters were in operation at Birmingham, Salford, Accrington and York. London and Glasgow remained constant to chemical precipitation. In Germany, elaborate experimentation at the Hygienic Institute of Hamburg (founded 1894) under W. T. Dunbar, at the Experiment Station at Grosslichterfelde under Schweder (1897-8) and at the Royal Testing Station for Water Supply and Sewage Disposal at Berlin (founded 1901) were uniformly against septic tanks and in favor of contact beds, with a more recent trend of opinion (Schury, 1905) in favor of trickling filters. The methods employed in all the German cities are set forth *seriatim* in the massive Sewage-Lexikon of Hermann Salomon (Jena, 1906-11). In France, experimental work upon biological and chemical purification at the Madeleine Station under Albert Calmette is recorded in eight elaborate reports (Paris, 1905-8). In the Dutch cities (Amsterdam, Rotterdam, Delft), the pneumatic pumping system devised by Liernur (1867), has been employed. In 1903, there were 23 intermittent filter areas in Massachusetts, while the septic tank was introduced at Urbana (1894) and Champaign (1895-7), Kewanee (1898) and Lake Forest (1902), Illinois, Fond du Lac, Madison (1901), and Wauwatosa, Wisconsin (1902), Mansfield, Ohio (1902), Saratoga, N. Y., (1905) and elsewhere. The only large trickling plant is at Madison (Winslow). Of 1524 American cities in 1905, 1100 had sewerage systems and 90 purification plants, viz., 14 irrigation areas, 13 chemical precipitation plants, 29 septic tanks, 41 intermittent sand filters and 10 trickling filters.

The latest development in the treatment and utilization of sewage is the *activated sludge process,* devised and developed by G. J. Fowler, at Manchester, England (1912),[13] out of certain experiments on the aeration of sewage in tanks by Clarke and Gage at the Lawrence Experiment Station. The first exclusively activated sludge plant in this country was the testing station at Urbana, Illinois (1914), which was followed by a similar installation at San Marcos, Texas (1915), two large plants at Houston, Texas (1917) and the gigantic system of the Milwaukee Sewerage Commission (1913-24). Activated sludge treatment consists in preliminary filtration of the sewage to be treated through 1/8-1/16″ grating; rapid sedimentation of sand in grit chambers; aëration by admixture with activated (aërated) sludge, by influx of compressed air through piping below (aëration tanks), or by the mechanical process of mixing by machinery; sedimentation of the sludge from this mixture in sedimentation tanks; re-öeration and re-sedimentation, if necessary; and subsequent use or sale of the

[13] G. J. Fowler: Tr. xv. Intermat. Cong. Hyg. & Demog. (1912), Wash., 1913, iv, 375-183.



Aeration Tanks at the North Side Plant at Houston, Texas

dried sludge as fertilizer or fuel. The process is usually effected in the rectangular or circular tanks devised by Carl Imhoff in 1906, and has been very extensively perfected in Germany, particularly in the system of open and closed canals with Imhoff tanks employed in the Emschertal. The Imhoff or Emscher tank consists of two deep settling basins, one above and inside the other, and combines the merits of the sedimentation tank and the sludge digestion tank, into which the settled sludge would ordinarily flow before the septic tank effect has set in. In the Imhoff tanks, the sedimentation chamber is built into the sloping sides of the upper part, with a slot in the bottom for evacuation of the solids into the sludge compartment below. The lower part is thus a septic tank. The slot is so constructed that one side overlaps the other, forming a trap to prevent the fermenting solids from reentering the sedimentation chamber. This ingenious system is now in use in many cities of England, Germany and the United States.

In an outline sketch of this brief compass, it would lead us too far to attempt more than a rapid survey of

the present status of sewage disposal and water-supply in modern cities, the basic material of which is often scrappy, disparate, inconclusive and widely dispersed in space and time. Two outstanding American systems are of particular interest, *viz.*, those of Chicago and New York.

In the early days (1833-37), Chicago got its water in the usual hand-to-mouth way, then in part through the Chicago Hydraulic Company (1840-51), then from Lake Michigan by water-works built by the city (1851-4), later by tunnels (completed 1867) extending from the intake cylinders at the bottom of the lake (enclosed in gigantic "cribs" loaded down with rocks) to the Central, Lake View, North Side, West Side, 14th Street and Hyde Park (68th Street) pumping stations, with reservoirs at Washington Heights. As the sewage and industrial wastes were emptied into the Chicago River and carried into the Lake, pollution of the water had become a nuisance even before 1870, and the Illinois and Michigan Canal (authorized, 1821, built 1836-48) proved inadequate to meet the difficulty. The street sewers were poor, the corner gutters were clogged with filth, which ran over into the streets and became massed under those which were planked, while the people drank their own sewage from the Lake. The great fire of October 8, 1871 destroyed most of the wooden structures and resulted in a new city of brick and stone. On July 1, 1889, Chicago and its suburbs was organized into a Sanitary District of 185 square miles for a population of 1,149,738. By 1925, this had expanded to 437.39 square miles, covering Chicago (199.38 square miles, population 3,350,000) and 49 other cities and villages. The New Drainage Canal, which reversed the flow of the Chicago River uphill from the Lake into the Desplaines River, was constructed in 1892-1900, with a system of intercepting sewers (1898) to prevent drainage of surplus sewage into the lake. Permission to open the Canal was granted by the Federal Government on May 9, 1899, with subsequent restrictions on the amount of Lake water with which the canal sewage was to be flushed. A bargeway, the Illinois and Mississippi or Hennepin Canal, was constructed about the same time (1892-1907) and opened on October 24, 1907. With the opening of the New Drainage Canal there was an immediate fall in the death rate and typhoid mortality rate in 1900, but an ominous rise in both during 1901-5. An extension of the main channel was effected in 1903 and in 1908-10, the North Shore channel, diverting North Side sewage from the Lake into the Chicago River, was constructed. The Lake Front Sewer (1913-16) and the Evanston Sewer (1916-20) diverted all lakeward flowing sewage of these districts into the North Shore Channel. The sewage of the Calumet district was diverted from the Lake by the Calumet Sag Channel (1912-22), which reversed the flow of Little Calumet River to the main channel at Sag, 22 miles southwest.[14]

[14] R. W. Putnam: Mil. Surgeon, Wash., 1926, LVIII, 243-258.

On March 3, 1925, the Secretary of War authorized Chicago to withdraw 8500 cubic feet of Lake water per second to flush these drains, provided it installs a system of artificial sewage treatment adequate for 1,200,000 people at the expiration of the project. Experimental sewage-testing stations had been built and operated at 39th street, the stockyards, Argo and the North Side from 1908 to date, resulting in an arrangement of the Sanitary District into six divisions, for sewage treatment, viz., the Des Plaines River, Calumet (1915-23), North Side (1922-9), Industrial wastes, West and Southwest Side projects, including an activated sludge plant on the North Side below 12th Street, the largest in the world (180 acres). The water consumption (800 million gallons daily or 275 gallons per head *per diem*) is to be cut down by metering, which will reduce the volume of sewage, while the sewage will be treated by sedimentation in Imhoff tanks, batteries of concrete aëration tanks (24 each), trickling filters and the activated sludge process. The program will be completed in 1940, five years earlier than anticipated.

In colonial and post-revolutionary days, New York City water was drawn mainly from wells, streams and ponds now filled in. A system for drawing water from Collect Pond was installed by Christopher Colles (1738-1821) in 1774-6, but never used. The Manhattan Company, organized (1779) to supply the city with water, devoted itself mainly to the banking business. In 1829, the city built a reservoir at 13th Street, and in 1837-43, the Old Croton Aqueduct. The use of Croton water was suggested by DeWitt Clinton in 1830. Water from the Bronx River was introduced in 1854. The Bronx River Conduit (1880-85) and the New Croton Aqueduct (1884-93) were the main sources of additional supply before the introduction of Catskill water from Scoharie and Esopus Creeks. Water was brought in from the Byram River (Catskills) in 1896-8-9. After the organization of the new Water Supply Commission (1905), the supply from the two Croton Aqueducts and the Bronx River Conduit was 415 million gallons daily. The Catskill system comprises the great Ashokan Reservoir, 22 miles north of the city, with a capacity of 130½ billion gallons, storing water from the combined Scoharie and Esopus water-sheds; the Catskill Aqueduct (1905-17), 110 miles long, passing from the reservoir under the Hudson to the Kensico Storage Reservoir (White Plains), thence to a filtration plant near Scarsdale to the Hill View Reservoir (Yonkers), with a capacity of 900 millions, to be delivered thence to the five boroughs by an 18 mile tunnel through solid rock. A new tunnel, from Hill View Reservoir to Brooklyn was authorized on March 10, 1927. The other distribution reservoirs are the Central Park, Clove, High Bridge, Jerome Park, Mt. Prospect, Silver Lake, Williamsbridge, and three of the Ridgewood System, from the Central reservoir at Hempstead. The Kensico Dam across the Bronx River Valley is one of the largest in the world, rising 307 feet above the rocks on which it rests. The total supply from the 24 reservoirs (276,086 million gallons) is about 1000 million gallons daily, the consumption (1925) about 865 million gallons *per diem*. The sewerage of Manhat-

tan goes back to 1676, when a brook flowing through Broad Street was converted into an open sewer, which was still functioning when Waring reported on it in 1886.[15] A network of drains, originally for swamp areas, spread out from this axis, and as the population increased, each street had its sewer of brick or stone, emptying into the North or East River. With the introduction of Croton Water, most of the sewers continued to empty into the old drains, which were not self-cleansing, nor adapted to the increased intake and were sometimes washed to pieces. In 1849, the construction and maintenance of New York sewers was taken over by the Croton Aqueduct Department. At this time, there were about 69.3 miles of sewers for a population of half a million. Construction now kept pace with the rapid growth of the city at the rate of about 12 miles of sewers per annum, so that by 1855, the total sewerage was over 140 miles. As the construction of new sewers, at the instance of land owners or of the city surveyor, was spontaneous, hap-hazard and sometimes worse than faulty, the greatest confusion reigned. Following the drastic reports of the Croton Aqueduct Board (1863-4), the sewerage act of 1865 was passed, authorizing the adoption of a general system for a population of 750,000. An organized corps of engineers made surveys and plotted the city into drainage areas, but with 200 miles of sewers on their hands, some of them unrecorded and in Carlyle's phrase, "tending nowither," nearly every street on the water-front had an outlet sewer, with consequent pollution and clogging of the river. With hundreds of old basins, new intercepting sewers were built. The first collecting sewer was built on the West Side at 11th Street in 1868, and the system was extended up to 17th Street by 1880. In 1865, sewers of strong vitrified piping from England and Scotland were substituted for brick structures. Much of this work had to be done through excavated rock at the rate of a cubic yard of rock for every foot of sewer. In 1870, the government of New York City was reorganized by charter, with a Department of Public Works controlling the sewerage (1871). At this time, there were many sunken lots below the level of the sewers, due to grading of streets by embankment above the ordinary level, and these became stagnant reservoirs of ordinary drainage and leakage from faulty sewers. By 1879, some 1391 land drains had to be constructed to carry off these accumulations. Meanwhile the enormous discharge of ordinary sewage continued to be a nuisance on the water-fronts. This combination of hap-hazard construction in chemical improvements and pollution of the three rivers went on through the dark days of the Tweed administration and later. During 1894-7, some improvements in street-cleaning were effected by Colonel George E. Waring (1833-98), at that time the American authority on sewage disposal. In consequence of two reports of the New York Bay Sewage Commission (1905-6), the Metropolitan Sewage Commission was appointed by the Legislature in 1906 and rendered three voluminous reports in 1910, 1912 and 1914. The sense of these reports

[15] G. E. Waring: Report on the Social Statistics of Cities (U. S. Census), Washington, 1886, Part I, 568-587.

was that interference with the local sewerage systems was unnecessary but that the main drainage system should be modified by intercepting conduits collecting the local sewage and conveying it to central plants for treatment so that a pure effluent could be discharged into the harbor waters. By 1910, there were over 500 sewer outlets along the waterfronts and, according to Soper,[16] the quantity emptied daily (600 million gallons) "would fill the East River at the Brooklyn Bridge for a distance of 1/5 of a mile, while the sewage produced in the Metropolitan District alone would fill the Flatiron Building at 23rd Street every 43 minutes." Manhattan Island came to be described as "a body of land entirely surrounded by sewage." The detailed plans of the Metropolitan Commission, which were to be completed at the intervals 1916, 1920, 1925, 1930, at an estimated total cost of $51,469,400, were opposed by the engineers of the Sewer Plan Commission, appointed by the Board of Estimate and Apportionment and ultimately merged with the Bureau of Public Improvement (1916). Acting upon a basis of agreement arrived at by the two Commissions, the Board of Public Improvement proposed to clean up the Harlem and East Rivers by intercepting the sewage, treating it in sedimentation plants and discharging it into the Hudson at a point north of the Spuyten Duyvil Bridge; by tunnelling it under Harlem River and 155th street; by screening or sedimentation at the end of 132nd street, with subsequent tunnelling to treatment plants at Ward's or Riker's Islands or Sunken Meadow, with other treatment plants on the lower East River side. The Report of the Public Health Committee of The New York Academy[17] of Medicine (September, 1918), prepared by Dr. E. H. Lewinski-Corwin, discusses at length the points at which the Committee and the City Engineers were in agreement or disagreement and in view of the expensive character of the proposed layout (estimated at over $50,000,000), recommends that the Board of Estimate and Apportionment adopt suitable plans to relieve the pollution of the harbor waters and make the proper appropriations for their execution. Beyond setting aside part of Wards Island for a sewage treatment plant, nothing further has been accomplished to date.

With the almost incredible growth of large cities before the World War and after, the improvement of sewerage and water-supply system became imperative, even in such tropical or semi-tropical centers as Alexandria (1905), Cairo (1910-25), Madras (1924), Constantinople (1915), and Peking (1911). Cities like Berlin, Cologne, Münich, Naples, Paris and Vienna, once disgraceful for bad smells and worse sanitation, now possess plants for sewage disposal and water-supply which are the admiration of Europe. They effected an astounding reduction in disease

[16] G. A. Soper: Tr. Am. Inst. Chem. Engineers, N. Y., 1910, III, 364-373.
[17] Med. Rec., N. Y., 1918, XVIV, 502-506.

incidence and mortality rates from water-borne diseases. The Revolution of 1911 gave a new sewerage and water-supply system to Peking and similar improvements were undertaken everywhere after the World War. Only passing and tabulated reference can be made to the water-supply systems of such cities [18] as

BALTIMORE:

From Jones River and Great Gunpowder Falls (1807-54) by tunnel to 8 reservoirs; distribution by gravity (low service) and pumping (high service). Gunpowder Aqueduct (1875-81). New Dam at Loch Raven (capacity 2 billion gallons) and filtration plant at Montebello. New sewerage system over Fallsway (1905-16).

BERLIN:

Originally from wells. Stralau water-works constructed by Fox and Crampton (1856), purchased by the city (1874), displaced by supplies from Tegel Lake (opened September 23, 1877), with 21 sand filters, and Müggel Lake (1890-93), with 22 filters and 8 reservoirs at Lichtenberg. Experience of Hamburg with water-borne cholera led to adoption of Koch's rules, viz., 1. Rate of filtration never more than 4 inches per hour. 2. Daily bacteriological examination of each filtrate. 3. Rejection of any filtered water containing more than 100 bacteria per cubic centimeter. Encroachment of factories and dwellings led to abandonment of surface supply for subterranean. Tegel Lake now tapped by 118 tubular wells and Lake Müggel by 349 wells (1901-3).

BIRMINGHAM:

Originally from neighboring wells and rivers (20 million gallons). Plan of supply from watershed of Elan and Claerwen Rivers, Wales (1891-2). Radnorshire aqueduct, 74 miles long (1892-1904). New supply opened by King Edward VII, July 2, 1904, followed by construction of masonry dams forming two reservoirs in Elan River, with 30 filter-beds (27 million gallons in 1904). Three dams and reservoirs in Claerwen River will yield 75 million gallons.

BOMBAY:

From Vehar Lake made by damming the Garpur River, Tulsi Lake (1872), Pawai Lake (1890) and the Tansa Reservoir, formed by the Great Tansa Dam, 118 feet high (1891), enclosing a lake 8 square miles in area, supplying 33 million gallons daily. Formally opened by the Viceroy, Lord Landsdowne in 1892.

[18] Valuable tabulations of the water-supplies of American and Canadian cities were made in the Manual of American Water-Works, Fourth Issue, New York, 1897, now unfortunately discontinued.

BOSTON:

From Jamaica Pond Aqueduct (1796-1893), Lake Cochituate (1845), Sudbury River (1878), Mystic Lake (1864-74) and South Branch of Nashua River (Metropolitan Water Board, 1895). Wachusett Lake Reservoir at Clinton (1896-1906) is the largest in the world (area 6.55 square miles; capacity 63 billion gallons).

BUFFALO:

By pumping from Niagara River (1852); new system with filtration plant (1926).

CALCUTTA:

From Hoogly River, 16 miles above city; iron reservoir, second largest in the world, just completed at Racla.

CINCINNATI:

By pumping from Ohio River (1820-96).

CLEVELAND:

By pumping from Lake Erie (1854-6); new filtration plant (1929).

DETROIT:

By pumping from Detroit River (1827); later an exceptionally pure supply from Lake St. Clair.

GLASGOW:

From Loch Katrine by aqueduct 35 miles long (1859), with subsequent raising of lake (1895), tunneling of Loch Arklet (1895) and building of the Loch Arklet dam (1909).

HONG KONG:

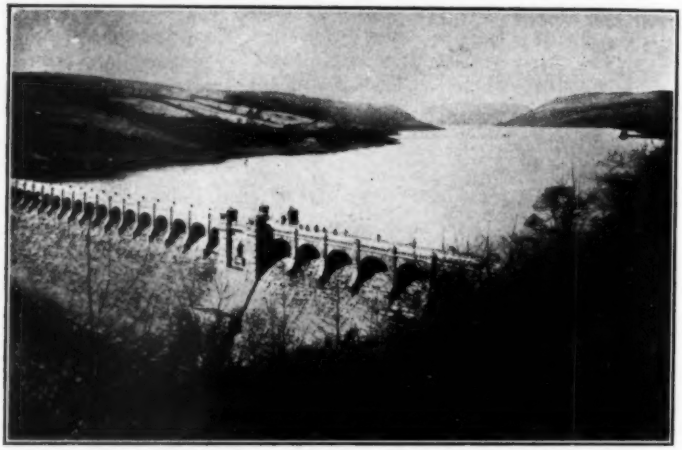
From rainfall by Pokfolum and Tytam reservoirs (total capacity 458 million gallons). Reservoirs now empty from recent drouth.

LENINGRAD:

From Neva by three water-works only one of which had sand filtration. Supply poor by reason of impurities gathered by floating ice. New plant for rapid filtration, clarification by aluminum sulphate and subsequent purification by 126 ozone batteries, with suction by Otto emulsors into 5 sterilization towers, built on site of old Penkowaya water-works by Siemens & Halske (1910-11). Tsarskoe Seloe supply from Gatschina-Taitzy Springs. Central Reservoir damaged by floods in 1924.

LIVERPOOL:

Originally from sandstone wells and works at Rivington (1847). Creation of Vyrnwy Lake, the largest reservoir in Europe (capacity 12 billion gallons), by impounding waters of Vyrnwy River (1880-92) by Vyrnwy Dam and subsequent tunneling of waters of Conwy and Merchant Rivers into this reservoir (opened by King George V, March, 1910).



Vyrnwy Dam and Aqueduct, Wales (Liverpool Supply)

LOS ANGELES:

By gravity from Crystal Springs 7 miles N. W. of city (1862-74). New supply from Owens River in the Sierra Nevada Mountains across Mohave Desert by an aqueduct 235 miles long (1913) a subterranean reservoir (Pacoima Dam) and 2654 miles of water-mains (1925).

MADRID:

From Lozoya Canal, 32 miles long. Additional reservoir (1883), construction of new water-works delayed by collapse of whole structure (April 8, 1905), with loss of 400 lives.

MANCHESTER:

From Irwell, Medlock, Irk and Tib Rivers (Longdendale Works, (1848-84). Increased supply by aqueduct from Lake Thirlmere (Cumberland), 96 miles away (1879-94), Haweswater scheme (1925-34) to comprise 84 miles of aqueducts, tunnels and pipes.

MANILA:

By gravity from Mariquina River into 2 billion gallon reservoir at Montalban (1908), 212 feet above sea level.

MARSEILLES:

From Durance River, opposite Pertuis, by Canal de Marseille (1837-48), 97 miles long, which crosses the Arc, between Aix and Roquefort, by the great aqueduct of Roquefavour, irrigates 7500 acres, purifies itself in the basins of Réaltourt and affords 2200 gallons per second for water-supply, sanitation and industrial works (2450 horse-power) to the city.

MELBOURNE:

From artificial Yan Yean Lake, 19 miles away.

MEXICO:

By Aztecs from springs at base of Chapultepec hill, with main causeway of city as dam. By Spaniards from three other springs by two long aqueducts. Later from other springs, the Rio Hondo (1899-1900) and 1386 artesian wells in the city.

MILAN:

From subsoil wells, 150 feet deep, using a tower of the Castello Sforzesco (Parco Nuovo) as a distributing center.

MILWAUKEE:

From Lake Michigan (1872-3) by pumping to reservoir and repumping to stand-pipes for high service.

MONTREAL:

By pumping from St. Lawrence River to reservoir and re-pumping to high service reservoir (1801-45). St. Cunegonde and other waterworks taken over by Montreal Water and Power Company (1889-94).

MOSCOW:

From Mystishchi Springs and ponds to fountains in city (1893). Distributed by water-carriers.

NAPLES:

In 17th century from Isclero River by an aqueduct which now supplies city fountains only. After the cholera, epidemic of 1884, from a hillside torrent (probably, from an underground lake) near Avellino by a covered masonry canal and iron piping to five gigantic reservoirs opposite Capedimonte Palace, thence by gravity to the city. The supply, icy cold and very pure, displaced all the infected wells in the city, which were closed as each new stand-pipe was erected. The sewage, which once rendered the bay unfit for bathing, is now conveyed by tunnels through Posilipo hill over the plain, to discharge into the sea on the deserted coast of Cumæ, 17 miles distant.

NEW ORLEANS:

By pumping from Mississippi River (1833). New system (1905-9), with screening and subsequent removal of aerial cisterns (1905), filtration by mechanical precipitation and distribution by 661 miles of watermains (1925).

PARIS:[19]

In Roman times, from Sources du Midi, supplying thermæ at Cluny by aqueduct of Arceuil (360), revived by Henri IV and reopened under Louis XIII, May 18, 1624. From Sources du Midi by aqueducts of Pré Saint-Gervais and Belleville (1457). Pumping into city by Samari-

[19] Diénert & Guellerd: *La Nature,* Paris, 1928, LI, 88; 108.

tan (1606), Notre Dame (1670), Chaillot (1781) and Gros Caillou (1781) pumps. Derivation of waters from Ourcq River (1782-1822) and artesian well in plains of Grenelle (1832). Program of Belgrand, (1854-1900), in connection with Baron Haussmann's improvements of streets, included:

A. Domestic supply from Seine basin, viz., Dhuis (1865) by 82 mile aqueduct to Menilmontant reservoir; Vanne (1868-74) by 108 mile aqueduct again crossing Arceuil by double bridge, to reservoir at Montsouris Park, to which also converges supply from springs at Loing and Lunain (1892-1900); Avre (1891-3) by 63 mile aqueduct to Montretont Reservoir (St. Cloud).

B. Public and industrial supply from pumping stations at St. Maur (1897) and Ivry (1899); from Ourcq Canal (1801-1822) and from artesian wells and old aqueduct of Arceuil. Distributed to city by high and low pressure. Work on new supply from springs in valleys of Seine, Marne and Aube in progress (1923-9) but interrupted by inundations of 1910 and the World War (1914-18).

PHILADELPHIA:

By pumping from Schuylkill and Delaware Rivers, with high service pumping from reservoir to stand-pipe (1799-1860). Water-borne infections checked by new filter-plant (1901-8).

PITTSBURG:

By pumping from Allegheny River (1826-78), with slow sand filtration plant.

RIO DE JANEIRO:

Formerly from small streams in the Sierra da Carioca by the old Carioca aqueduct, crossing the gap between Santa Thereza and Santo Antonio Hills by a bridge of double arches now used as a viaduct for the city tramway. Since 1885, from the Serra do Tinqua by the Rio de Ouro water-works, with 33 miles of iron mains between the collecting reservoir and the main distributing reservoir at Pedregulho.

SAINT LOUIS:

By pumping from Mississippi (1831), settling basins and conduit (1892) and chemical purifying plant (1904).

SAN FRANCISCO:

By gravity from mountain springs by single main (1856-74). After fire and earthquake by five independent systems. New Hetch-Hetchy system from headwaters of Tuolomne River in Sierra Nevada Mountains (1914-25). Dam and reservoir in Hetch-Hetchy Valley completed 1923. Tunnel (18 miles) to power-house at Moccasin Creek (1925). O'Shaughnessy Dam in Yosemite Valley (capacity 400 billion gallons daily) completed in 1929.

TOKYO:

From Tama River *via* Yodobashi reservoir.

VIENNA:

By Kaiserbrünn aqueduct direct from the Schneeberg (Alps), 56 miles away (1869-73). New sources tapped, 1891-3. New supply from Salza, 150 miles away (1902).

WASHINGTON:

From Potomac by aqueduct from Great Falls 12 miles long, spanning Cabin Johns Bridge. Constructed by U. S. Government (1853-1929). Sand filter (1896-1906). New system (180 billion gallons daily) nearly completed.

In attempting to drive a four-in-hand of themes of such vast scope, each of them coextensive with the story of man himself and none as yet provided with an adequate and sequential history, the difficulty is intensified by the intractable and evasive character of the material. Even such a slight performance as the present sketch had to be pieced together from scattered (or successfully buried) data of archæology and sanitary engineering, from guidebooks, government reports, travel sketches, magazine articles and even world almanacs. While not a syllable about our quadrivium will be found in the average lengthy treatise on *Culturgeschichte,* the basic theme (domestication of water) is surely one of the most fundamental and picturesque conceivable, in the view of some thinkers, the starting point of civilization. The incredible irrigation tanks of Ceylon, the great Assyro-Babylonian drains and water-courses, the Aqua Claudia and the Cloaca Maxima, the Pont du Gard and Nadrai Aqueduct, the Queen Mary Reservoir and Vyrnwy Lake, the sewage farms outside Berlin and Paris, which furnish half their vegetables in season, such imposing massive walls of upreared masonry as the Vyrnwy, Tansa, Kensico, Elephant Butte and Shoshone Dams, or such feats of engineering as the Chicago Drainage Canal or the raising of Loch Katrine, are among the ways and works of man which Carlyle liked to herald as "legible through the solar system." About them hovers the dramatic element of moving accidents by flood and field, such as the capsizing of the Bousey Dam, the Johns-

town Flood, the break-up of the Madrid reservoir, the terrible inundations which have overwhelmed our Mississippi and Colorado areas—fatalistic and "fortuitous concurrences of physical forces," which sweep away human settlements like ant-hills and dwarf man himself into insignificance. In keeping with the gravity and risks of such serious enterprises, the opening of aqueducts, reservoirs and drainage canals, like the christening of a battle-ship, is usually a matter of festal pomp and circumstance, from the days when the Lord Mayor of London rode to the conduit heads to the opening of the Queen Mary Reservoir by George V or the annual festivities attending the opening of the ornate lower dam at Guanajuato (Mexico) on St. John's Day (June 24), just before the rainy season, a veri-

Fiesta at the Lower Dam at Guanajuato (Mexico) on St. John's Day (June 24), before rainy season

table *Fiesta de la Presa*. Again, about all rivers there is the important legal question of riparian rights, with reference to the poisoning of streams by industrial or domestic sewage, as in the suits brought by Millbury, Mass. against

Worcester or by Missouri against Chicago, or the pending dispute between the states on the Ohio River and the question of Federal intervention, which turns upon the interpretation of a single word in our Constitution. About all still or flowing waters, too, there is the inevitable romantic aura, from the Song of Solomon to Swinburne's "weariest river," from the "pure river of water of life" (Revelations, xxii, 1) to Goethe's *Bächlein* or the *Schilflieder* of Lenau, from Mendelssohn's *Melusine* to such *jeux d'esprit* as *Au bord d'une source* (Liszt), *La Fontaine* (Henselt) or the *Barcarola* of Rachmaninoff. The opening of *Rheingold* is suggested by what Richard Wagner said to Edmond Schuré on the bridge at Basel: *"La nymphe exquise que cet eau—c'est traitre et fuyant comme la vie!"* In one of the clairvoyant moods which he sometimes had, the sombre Pascal opined that "Rivers are but roads in motion" (*Les rivières sont des chemins qui marchent"*). And it has not escaped the observation of poets that the sometimes tortuous course of a stream is not unlike the uncertain chances and mischances of human life, from youth to age—

> "But the majestic river floated on,
> Out of the mist and hum of that low land,
> Into the frosty starlight and there moved,
> Rejoicing through the hush'd Chorasmian waste,
> .....
> Brimming and bright and large; then sands begin
> To hem his watery march, and dam his streams,
> And split his currents; that for many a league
> The shorn and parcell'd Oxus strains along
> Through beds of sand and matted rushy isles,
> Oxus, forgetting the bright speed he had
> In his high mountain cradle at Pamere,
> A foil'd circuitous wanderer."

As life is motion, there is, as the Spanish proverb observes, an element of uncertainty in all smooth, still, dammed up waters, which is apt to revenge itself upon mankind (*Del aqua mansa me libre Dios!*). The loss of life entailed by the bursting of great dams and the overflow

of pent-up torrents is a subject of strictly hygienic interest, as much the concern of preventive medicine as of stress, strain and strength of materials. It bespeaks the overweening confidence of great nations in the days of their might, the hazards attending the immense proliferation of populations up to the saturation point which preludes decline, and how medicine is in touch with human activity on every side.

F. H. GARRISON.

# ALLERGY AS ENCOUNTERED BY THE GENERAL PRACTITIONER

WM. W. DUKE
Kansas City, Mo.

*Delivered January 4, 1929, in the Friday Afternoon Lecture Series of The New York Academy of Medicine.*

I understand that it is the wish of The New York Academy of Medicine to have presented in this lecture a survey of our knowledge of allergy as related to the general practice of medicine. Since this is my understanding of the object of the lecture, I shall confine my discussion to the practical points in allergy which can prove interesting to the general practitioner and shall avoid a discussion of theoretical points which are interesting to specialists, but which cannot at the present time be applied practically. I can assure you there remains an abundance of material which is both interesting and useful.

In 1910 Meltzer made the suggestion that bronchial asthma is a phenomenon of anaphylaxis. Regardless of the fact that the accuracy of this statement may be questioned, certain it is the suggestion has directed attention to an important class of diseases and a productive study has resulted. From recent investigations, we have learned to diagnose and treat illnesses which previously were overlooked or were not understood, or were not amenable to treatment.

It was observed by Magendie as early as 1839 that dogs which had been repeatedly injected with egg albumen often died suddenly. At a later period, Richet observed that animals injected with eel serum became sensitive to it so that second doses too small to be harmful to normal animals caused violent symptoms or death in the animals which had previously been inoculated. To this peculiar condition he gave the name anaphylaxis. In the earlier days of the development of this subject, we were inclined to believe that food idiosyncracies, pollen sensitiveness, and illnesses following serum injections were closely related to the condition produced in animals by second doses

of serum. This apparently is not a correct viewpoint, for we find it is very difficult to sensitize human beings by one or several injections of extraneous material. It led to the discovery of the fact, however, that in humans we have a hereditary condition in which a person spontaneously becomes sensitive to some alien substance and reacts violently upon intimate contact with it. For the recognition of the importance of heredity in the allergic consti-

FIGURES I-II—Typical chest deformity caused by perennial asthma in growing children. Note the increased anterior posterior diameter and marked dorsal kyphosis. This tendency is not pronounced in seasonal cases since the well period as a rule allows complete subsidence of the deformity. This deformity is also not so pronounced in individuals in whom the condition starts after the period of growth is complete.

tution and still more for the directing of the attention of physicians to the reality and importance of this class of diseases, we should feel grateful for the researches of Drs. Coca, Cooke, Vander Veer and their associates. Also for the early writings and investigations of Vaughan, Koessler, Walker, Rackemann, Lawdermelk and others.

FIGURES III-IV—The troubled face of the chronic asthma patient in youth and after the condition has persisted into adult life. Note the paranasal depression in both illustrations. This is a frequent finding in perennial cases which start during the period of growth and development. It is caused, I believe, by oedema in the paranasal tissues which impair their normal development. This deformity is not pronounced in seasonal cases. The well period apparently allows time for recovery of the tissues. It is not pronounced in individuals in whom the condition starts after development is complete.

*Extreme Degree of Sensitiveness*—The extreme degree to which this type of sensitiveness can develop is almost beyond belief. It can be so extreme that a common wholesome food stuff such as egg may come to rank in a sensitive patient with the poison of a venomous reptile in its capacity for causing illness—in fact, I know of few poisons comparable with an allergen in a highly sensitive case except diptheria toxin and tetanus toxin. Fortunately, sensitiveness of this extreme grade is uncommon. Sensitiveness in milder grade is common. I can easily illustrate high grade sensitiveness by stating that I have had three egg sensitive cases who could be made ill by eating the trace of egg in hen meat. They could tolerate rooster meat with impunity. It is well known that certain infants are made ill by mother's milk and that the illness can be traced to certain foods eaten by the mother to which the infant reacts. If these foods are eliminated from the mother's diet, the milk may agree with the infant. I have observed a number of patients who could be made violently ill by as little as one drop of honey. It can be readily understood that the substance which made them ill must have been ridiculously minute in amount for it is a known fact that if the sugar is removed from honey by dialysis and water by evaporation, practically nothing remains. I might finally illustrate high grade sensitiveness by citing the fact that I have observed three individuals who were sensitive to egg and suffered from eczema, asthma, or both upon contact with egg. Each of these three patients were relieved completely when egg was removed both from their diet and removed from the house in which they lived. In each case recurring attacks of eczema or asthma or both could be traced to the fact that egg was carried to the patients by individuals who had recently eaten egg. It is actually a fact that a mother's kiss can be violently poisonous to an egg sensitive infant if the mother has recently eaten egg.

*Origin of Sensitiveness*—Two factors seem important in the origin of sensitiveness to foreign matter. One is a peculiar hereditary constitution which permits an indi-

vidual to become sensitive to foreign matter. The other, peculiarity of exposure. Patients apparently become sensitive to materials which they meet with in traces rather than to materials which they encounter grossly. For example, it is uncommon to find a patient sensitive to milk casein. They are more likely to become sensitive to a substance contained in milk in infinitesimal amounts. They are more likely to become sensitive to the pollen of the air which they encounter in traces than to materials of diet which they encounter grossly. The fact is, that if a person were sensitive to something which he encountered in gross amounts at daily intervals, he should either die from gross exposure to the substance or gain tolerance for it.

*Duration of Sensitiveness*—Sensitiveness, once acquired, is likely to be permanent. This is more true of sensitiveness to air carried substances than it is in the case of sensitiveness to foods. This latter condition is probably due to the fact that in the case of food sensitiveness, a person often reacts to a split product of a food rather than to the food as it exists in nature. If digestive processes change so that certain products are not elaborated or not absorbed, we might explain theoretically why a patient should cease reacting to a food which at one time apparently caused illness.

*Specificity of Sensitiveness*—Sensitiveness in humans is frequently highly specific. For example, individuals sensitive to foods such as strawberries, or cantaloupe may react to the product grown in one locality and may tolerate the product grown in another locality. This apparent high grade specificity is not difficult to account for when we realize there exists differences in flavor of foods grown in different areas. Foods grown in certain areas certainly must contain chemical bodies which do not exist in the same food grown in another locality.

*Multiple Sensitiveness*—Certain individuals are sensitive to one agent only. The majority are sensitive to more than one. Patients sensitive to pollen may also be sensi-

tive to a food or animal dandruff or may also be sensitive to physical agents such as heat or cold or light or scratches. Whereas, multiple sensitiveness is a recognized condition, some patients who apparently react to almost everything, are often found sensitive to one or several agents which have a wide distribution in nature.

## Agents Which Tend to Sensitize

*Pollen*—Pollen is probably the most common single cause of sensitiveness in human beings. A patient who is sensitive to pollen reacts, as a rule, to the pollen which is found most abundantly in the air of the district in which he resides. Three classes of pollen are important. The pollen of the trees, which may give rise to spring cases of so-called hayfever, asthma, or dermatitis; the grasses which may give rise to summer cases; and the weeds which may give rise to fall cases. Flowering plants are relatively unimportant in the causation of reactions because of the fact that the pollen of flowering plants is not produced in large quantities. It also has a tendency to adhere to the plants from which it is produced. The pollen of flowering plants is carried from plant to plant by insects

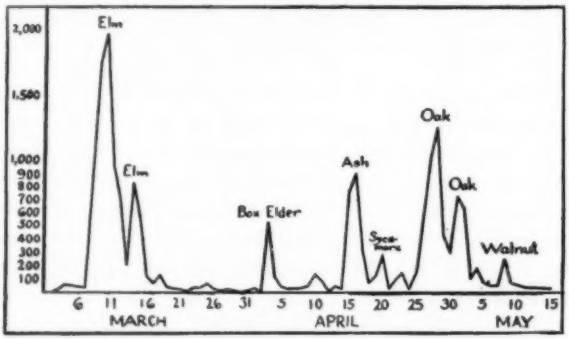



Figure V—Tree Season, 1927—The pollen content of the air during the tree season 1927. Note the peaks caused by pollenation of the different trees. These peaks usually appear on bright windy days. Wide spread rain usually filters pollen out of the air so that after a rain we often find a sharp drop.

rather than by wind. Very few individuals are actually made ill by the pollen of a flowering plant. They are occasionally made ill, by emanations from the leaves or petals of flowering plants

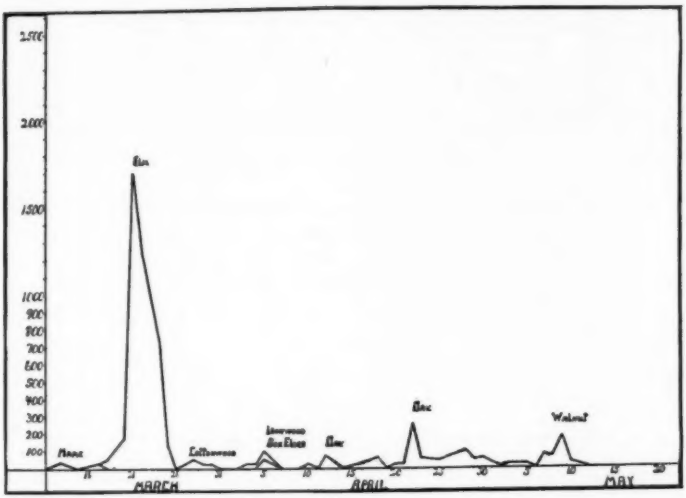



FIGURE VI—The Tree Season, 1929—Note the difference between Figure V and Figure VI. The pollenation of the trees in 1929 was stopped by frequent slight spring frosts.

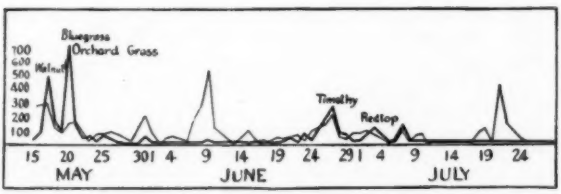



FIGURE VII—Grass and Spore Season 1927. Note the peaks caused by the various grasses. The thin line represents the spore count. The relationship between spores and summer symptoms has not been adequately studied. From the magnitude of the spore counts, one would imagine that it would bear an important relationship to summer symptoms.

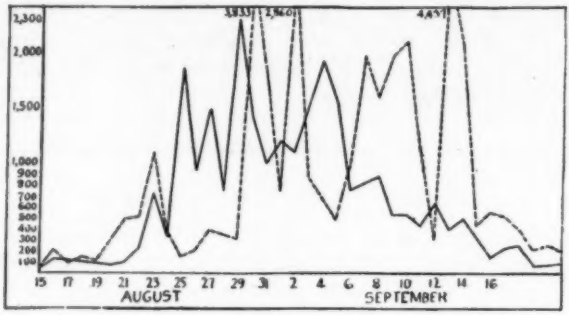



FIGURE VIII—Ragweed Season 1926 and 1927. Note how long is the season as compared with that of any individual tree or grass season. There is less variation in the intensity of the season in different years as compared with the tree season due to the fact that pollenation is not so frequently impaired by frosts.

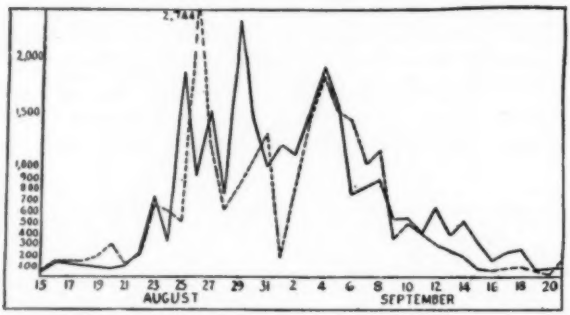



FIGURE IX—Ragweed Season 1927. Comparison of counts made in suburbs (solid line) and in the downtown district (broken line). This chart illustrates the fact that the proximity of weed patches does not make the gross difference in the pollen content of the air which one would expect. The fact is, that on windy days pollen is picked up from areas of a hundred miles or more. The additional pollen picked up from neighboring weed patches does not make the gross difference in the counts which one would expect.

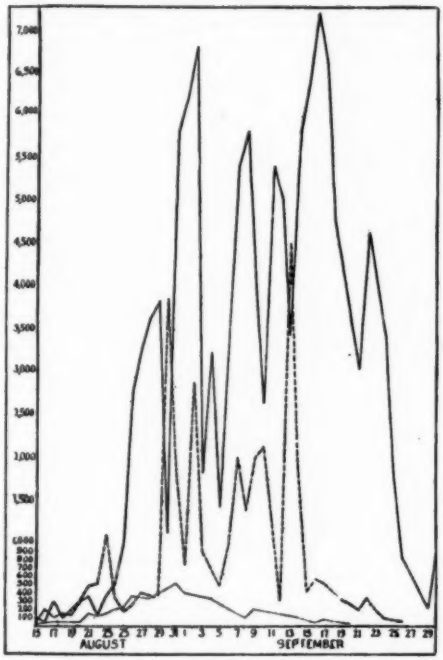



FIGURE X—Charts showing the gross variation in the pollen content of the air of different geographical districts. Solid line—Oklahoma City. Dotted line—Kansas City. Fine dotted line—Chicago. Counts made in sea coast districts such as New York, Richmond, Virginia, Oakland, California, are much lower on an average even than in Chicago and are small, indeed, as compared with inland cities such as Kansas City, Indianapolis, and Oklahoma City. This is due, no doubt, to the fact that in inland cities, the air has a sweep of wider areas covered with pollenating plants.

A study of the pollen content of the air yields extremely interesting information which explains the peculiar behavior of many individuals. Pollen does not constantly fill the air during the spring, summer, or even the fall months as we previously presumed, but fills the air for shorter periods of time and then nearly disappears. In Figure V to X, is shown the pollen content of the air observed at daily intervals in Kansas City during a period of one year. It can be observed that in March we have a peak of pollen production occurring coincident with the blossoming of elm trees. Other peaks occurring at later dates are coincident with the blossoming of box elder, ash, sycamore, oak, and walnut. Air pollens can be identified by comparing the pollen found on pollen plates with pollen collected from plants blooming abundantly at the time. Peaks of this sort are inclined to appear on sunny windy days. The pollen may disappear from the air almost completely with wide spread rain. During the summer months, peaks occur coincident with the pollenation of blue grass, orchard grass, timothy, and red top, and during the fall months coincident with the pollenation of the ragweeds. There is an interesting series of peaks during the summer months in Kansas City caused by so-called spores which are shown in Figure VII.

The spores found in the air in the middle of July could be identified with wheat rust and several patients who had hayfever at that time gave positive skin tests upon intracutaneous injection of a suspension of the spores of wheat rust.

Attacks of hayfever or asthma and, much less commonly, eczema, occur coincidently with the appearance of these peaks of pollen production. As a rule, testing with the pollen which is found in the air at the time the patient is having symptoms gives positive reactions and enables one to make a positive diagnosis as to the cause of the trouble.

It has been found in my cases that a rather large number of patients give seasonal reactions with symptoms such

as coryza and asthma at times when there is no pollen in the air. Furthermore, they are not found sensitive to pollen when tested. Cases of this type frequently are found sensitive to heat or cold and react to certain temperature changes. These will be referred to again subsequently.

It is common to find patients who have pollen hayfever who do not have pollen asthma. The reverse findings are unusual—that is pollen asthma in the absence of hayfever. It is believed that this is caused by the fact that the nasal membranes filter off a certain proportion of the pollen granules before it reaches the bronchial membranes so that the nasal membranes are, as a rule, more intensely exposed. Very frequently, when the pollen content of the air is very high, patients who ordinarily have hayfever alone will have, for a time, both hayfever and asthma. Pollen dermatoses are rare, but interesting when found. They can be diagnosed and treated with the same success as hayfever and asthma. Tests should be made by the application of pollen itself to the skin. This may give rise after a period of twenty-four hours to eczema similar to that of which the patient complains. We rarely find the striking hive reaction observed in hayfever and asthma cases.

The pollen content of the air does not vary as grossly in different neighborhood localities as one would expect. The pollen content of the air observed simultaneously by Durham in the suburbs of the city and by myself at my office in the heart of the city were almost identical on windy days. Pollen gets into the air in much the same way that dust gets into the air on windy days in dry regions. It is carried to great heights and for great distances. There may be little difference in the pollen content of the air near the ground and the air at the top of the highest buildings—in fact, in aeroplane studies which I made last year we found the pollen content of the air at a height of three thousand feet practically as great as the pollen content of the air near the ground.

There is a gross difference in the pollen content of the air in different geographical localities. In inland cities, such as Kansas City, the pollen content of the air is enormous. In a seacoast city, such as New York and Richmond, Virginia, or Oakland, California, it is very small. The air from the sea contains no pollen and the pollen of the air from the west which reaches the Atlantic coast is frequently filtered out of the air by rain in the Allegheny Mountains. Consequently, the pollen which reaches New York City comes from a relatively small district and does not reach the heights observed in middle west cities. Vaughan's counts made in Richmond, Virginia, and Rowe's counts made in Oakland, California, are scarcely ten per-cent as great as those found in Kansas City, whereas, Durham's counts made in Indianapolis and mine made in Kansas City are almost identical.

I previously mentioned wind as an important factor in the carrying of pollen. This factor is so important that patients afflicted with severe symptoms of pollen disease may be violently ill on a windy bright day whereas on a still day following a rain they may be almost completely relieved. I found that the pollen content of the air in a closed room is practically nil as compared to the pollen content of the outside air. Pollen falls quickly to the floor in a closed room. This makes an ideal place, therefore, for the treatment of a pollen sufferer. Conversely, the amount of pollen deposited upon pollen plates behind the propeller of an aeroplane is perfectly stupendous. More is deposited within thirty seconds than is deposited by still air in twenty-four hours. These facts account for the apparently erratic behavior of patients with pollen disease. Those who are highly sensitive may be relatively free of symptoms if they remain indoors and on the same day may have severe attacks if exposed to air in motion. A railroad trip is always hard on a pollen sufferer on days when the pollen content of the air is high.

Whereas pollen is the greatest single cause of allergic reactions, other agents are also important.

FIGURE XI—*Pollen Content of Still Air*

| | |
|---|---|
| Room closed 1½ years | 0 |
| Room closed 1 day (closed only 1 day) | 3 |
| Room closed 1 day with fan going 12 hours | 8 |
| Ventilated room, same day | 20 |
| Outside air count, same day | 191 |

FIGURE XI—Pollen Content of Still Air—A comparison of pollen counts (twenty-four hour exposures) made from a room closed one year; a room closed one day; a similar room closed for one day with air kept in motion twelve hours by a fan; a similar room ventilated by a window opened to the extent of six inches; and finally from the outside air. Note the gross and rapid reduction in the pollen content of the air caused by the prevention of air movements. Pollen falls quickly to the floor if the air in the room is still, so that after a few hours the air in a closed room is almost free of pollen. A fan carefully used need not stir up much pollen in a closed room. A closed room makes a good refuge for pollen sensitive individuals on days when the pollen content of the outside air is high.

## FIGURE XII

TABLE 3.—*Pollen Counts* *

| | |
|---|---|
| Ground aviation field (calculated) | 0.6 |
| Airplane propeller moving about half speed | 82.0 |
| Airplane rising to 200 feet, propeller full speed | 289.0 |
| Airplane at 400 feet, propeller full speed | 335.0 |
| Airplane at 600 feet, propeller full speed | 328.0 |
| Airplane at 1,100 feet, propeller full speed | 319.0 |
| Airplane at 1,600 feet, propeller full speed | 341.0 |
| Airplane at 3,000 feet, propeller full speed | 329.0 |
| Airplane at 4,000 feet, propeller full speed | 10.0 |
| Airplane at 5,000 feet, propeller full speed | 0.0 |
| Airplane at 6,000 feet, propeller full speed | 0.0 |
| Airplane at 7,000 feet, propeller full speed | 0.0 |
| Airplane at 8,000 feet, propeller full speed | 0.0 |

FIGURE XII—The Pollen Content of Rapidly Moving Air.—This chart represents counts made from pollen plates exposed thirty seconds to the air on the ground at an aviation field; behind the propeller of the aeroplane moving at half speed; behind the propeller moving at full speed; and behind the propeller at different heights from the ground. Note the small number of pollen granules deposited by the relatively still outside air as compared with the rapidly moving air behind the propeller of an aeroplane. Note also the fact that the pollen content of the air at the height of 3,000 feet is not grossly different from that at the height of 200 feet. One can infer that a rapidly moving train or automobile is a poor place for a pollen sufferer to be on days when the pollen content of the air is high.

*Feathers and Hair*—A certain small proportion of individuals are sensitive to hair or feathers and may react upon adequate exposure to certain animals. Patients of this sort are usually more sensitive to the animals than they are to the renovated fur or feathers. This type of reaction is important in individuals whose occupation brings them in intimate contact with animals to which they are sensitive.

*Smoke*—Smoke is a very definite cause of reaction in a very large number of cases. Patients can be just as specifically sensitive to certain types of smoke as they can be to certain types of pollen. For example, certain sensitive patients react to wood smoke, others to coal smoke, others to tobacco smoke. One patient I had was so sensitive to cigar smoke that the amount carried home on the clothes of her husband would cause her to have asthma. She could tolerate cigarette smoke. One patient sensitive to wood smoke was so highly sensitive that she could not remain many minutes in a room with an open fire place without having asthma. She had asthma regardless of whether a fire was burning or not. A scratch test with a solution of wood smoke gave such a violent reaction that adrenalin had to be given immediately for her relief.

*Dust*—Coca, Cooke, and associates have added a great deal to our practical knowledge from a study of dust as a specific cause of hayfever and asthma. They are able to extract substances from dust with which they can obtain positive skin tests and with which they can obtain good results in therapy.

*Foods*—Foods are a very definite source of hayfever, asthma, dermatoses, and gastro-intestinal upsets, especially in children. By far the commonest offenders are milk, eggs, and wheat. I have found pork to be a source of perennial symptoms in a small number of patients caused by daily contact with lard or bacon grease. Patients of this sort commonly give a history of asthma upon exposure to the fumes of frying grease and since food cases

very commonly give negative skin tests, this history is important in the diagnosis of pork sensitiveness.

*Drug Idiosyncracies*—It has been known for centuries that certain individuals are sensitive to drugs and react with symptoms which are similar in many respects to those of food idiosyncracies. Common types of sensitiveness of this variety are those caused by the salicylates, iodides, arsenical drugs, drugs of the atropine series, cocaine series, the morphine series, and the quinine series. Patients may become so sensitive to a drug that it is actually dangerous to use it in even minute amounts. A number of dentists have severe dermatitis from their infinitesimal exposure to the anesthetic which they use in nerve block.

*Bacteria*—It was formerly believed that bacteria were common sources of sensitiveness and gave rise to symptoms similar to those observed in pollen disease and in the food idiosyncracies. Most individuals are sensitive to certain bacteria in the same sense that tuberculous patients are sensitive to tubercle bacilli. However, I do not believe that bacteria give rise to the stormy symptoms characteristic of pollen disease except occasionally in the acute infections such as acute tonsillitis and rheumatic fever and scarlet fever. This view, however, is not shared by many observers who believe that bacteria are a common source of allergic coryza, bronchial asthma, and urticaria. Upon purely theoretical grounds one would believe that if an individual was sensitive to bacteria growing in his tissues, that constant intimate exposure would make him immune and that he would soon cease to react. This question, however, must be considered an open one at the present time. It has been extensively studied by Thomas to whose writings the readers are referred.

*Insects and Animal Parasites*—Insects such as mosquitoes, bees, bed bugs, etc., and animal parasites, such as round worms, may give rise to violent allergic symptoms. I know of one case of death which immediately followed the sting of a wasp. I have known of many cases who were so sensitive to certain insects, that they were made

profoundly ill by one or several bites. I observed one case of allergic shock which followed three insect bites and which would almost certainly have terminated fatally had it not been for the timely use of large quantities of adrenalin.

*Therapeutic Sera*—In a review of about eighty cases of death following a serum injection, Lamson found a history of hayfever or asthma in about half the cases. A first dose of foreign serum may cause a violent or fatal illness in patients who give a history of asthma, hayfever, or hives. It is advisable before administering serum to inquire for a history of hayfever, asthma, or hives, and in case a positive history is found either in the patient or his family, to make conjunctival tests with the serum before it is administered. In case of a positive test, it is urgent to avoid the use of serum unless an emergency such as proven diptheria justifies taking a gross chance of causing a serum death. Even with the finding of a negative conjunctival reaction, it is well to avoid the use of serum in hayfever and asthma patients unless it is definitely indicated. It should then be used in doses which are the smallest possible compatible with a good therapeutic result.

*Blood Transfusion*—I have had two cases of severe allergic shock occur during the course of blood transfusion in patients with a history of asthma. Both were relieved by the timely use of adrenalin, but one nearly resulted fatally in spite of this. Since these experiences, I have avoided transfusion in patients who give a history of hayfever or asthma. I would not hesitate to use transfusion, however, in an asthma case if the indications for transfusion justified taking a chance. The blood of patients and donors was compatible so far as iso-agglutinins were concerned in my two cases which were shocked. I attributed shock to sensitiveness of the patient to a food recently eaten by the donor.

*Sensitiveness of One Individual to Another*—This is usually attributable to some perfume or cosmetic worn

by an individual. A case was observed, however, by Dr. Manchester and one by myself of sensitiveness of an infant to the mother's menstrual secretion.

*Endogenous Allergy*—One wonders whether or not certain individuals might not become sensitive to some substances originating in their own body. I have had several cases of hives and angioneurotic oedema occurring in lactating women which could be relieved by a breast pump and which disappeared after lactation ceased. Also in several cases sensitive to light or cold, I wondered whether or not the individual could be sensitive to some new product formed in his own skin under the influence of light or cold. I have been unable to prove or disprove this point satisfactorily.

## Contributory Causes of Reaction

Many factors, such as mechanical agents, chemical irritants, light, heat, and cold, and the heat caused by functional activity can add to symptoms occurring as a result of sensitiveness to some other agent. It is a question with me, however, whether these factors are actually contributory causes of reaction or whether the patient is not specifically sensitive to the mechanical agent, or chemical irritant, or to light or cold or heat as the case may be, so that the two agents, acting simultaneously, elicit symptoms which are more severe than that produced by either one acting alone. A decision concerning this important point must be left for future work.

We know, furthermore, that reflexes, emotional disturbances, pregnancy, and lactation, defects in the endocrine secretions, nasal defects, and diseases in the alimentary tract may either cause or add to symptoms which are similar in many respects to that of typical allergy caused by foods or pollens. Occasionally lesions such as these seem to be primary causative factors of symptoms like allergic coryza or asthma. This type of case is also worthy of further study.

## Symptoms

Symptoms which can occur as a reaction of allergy are widespread. In fact, we might expect it to be possible for reactions to occur in almost any active tissue in the body.

*Shock*—Shock is the most tragic of all our symptoms. It is, fortunately, not extremely common. With the onset of shock, the patient usually complains of generalized itching, followed within a few moments by pain in the head or lower back, sneezing, cough, and within a few moments may totally collapse and appear breathless and pulseless. A severe reaction of this kind is usually associated with generalized erythema, frequently urticaria, frequently oedema, and frequently severe asthma. Under appropriate treatment with adrenalin the symptoms should reduce in severity or disappear within several minutes to thirty minutes.

*Orbital Symptoms*—Puffiness and itching of the lids, oedema of the conjunctivae, clear lacrimal secretion.

*Nasal Symptoms*—Sneezing, pale swelling of the membranes, clear watery or clear mucous secretion.

*Pharyngeal and Oral Symptoms*—Itching and oedema, especially of the soft palate and the pharynx.

*Laryngeal Symptoms*—Cough, hoarseness, pale oedema of the larynx and epiglottis.

*Bronchial Symptoms*—Cough, wheezing, bronchial obstruction, expectoration of cleary watery or mucoid sputum.

*Gastro-Intestinal Symptoms*—Abdominal pain, nausea, vomiting, diarrhoea, mucous colitis.

*Cutaneous Symptoms*—Pruritis, erythema, urticaria, angioneurotic oedema, and dermatitis of many types.

*Headache*—Occurs as a primary symptom of reaction or may occur as a result of oedema in the nasal sinuses.

*Neurological Symptoms*—Asthenia is common. More rarely we find parasthesia, anesthesia, and in very rare instances, convulsions or temporary paralysis or mental disturbances.

*Dizziness and Ménière's Syndrome*—Can apparently occur as a result of reaction in individuals who may have no demonstrable disease in the internal ear.

FIGURE XIII—Egg eczema in an infant who had for several months been kept on a strictly egg free diet. This little child was completely clear of eczema within one week after egg was removed both from the diet and from the house in which he resided. Simultaneously he began to grow and gain weight with great rapidity. Recurrences of eczema were traced to the fact that the parents would occasionally eat egg while away from home and soon after handle the baby. This would invariably cause a recurrence. Tested experimentally by having the mother handle egg with her hands and soon thereafter touch the baby, we found smears of eczema on skin areas which had been in contact with the mother's hand.

*Urological Symptoms*—Renal colic and irritable bladder.

*Miscellaneous Symptoms*—Disturbances in menstruation, arthritis, hypotension, and eosinophilia.

*Infection*—May be superimposed upon tissues reacting as above mentioned and may complicate the clinical picture.

FIGURE XIV—Shows the same child after it had been rid of egg eczema by its avoidance for a period of several years.

## SPECIFIC DIAGNOSIS

It has become a custom to place too much dependence and too much reliance in the results of skin tests in the diagnosis of allergy. The fact is that a careful family history, personal history, observations made by the patient in relation to the contact with or avoidance of certain articles, and actual practical testing by avoidance and contact with certain articles rank in importance, if they

do not exceed in importance, the results which can be obtained by skin tests. Unfortunately, skin tests are often positive for agents to which the patients do not react clinically and vice versa, agents which actually afflict the patient may give negative skin tests. The most reliable results to be obtained through the use of skin tests are with agents with which the patient comes in contact through the outside air—that is, pollens, animal hair, dust, etc. Skin tests with foods are usually disappointing.

Skin tests can be made in many ways and frequently it is advisable to make tests in several different ways. The intracutaneous tests should not be used by inexperi-

FIGURE XV—Illustration of series of tests with different materials in an individual suffering from pollen hayfever. The offender can frequently be discovered through observing the intensity of the tests. This means of diagnosis is subject to gross error unless one realizes that skin sensitiveness does not indicate clinical sensitiveness, and vice versa, patients who are clinically sensitive do not always give positive skin tests to the agents responsible for the trouble.

enced men. Scratch tests or tests made by the application of substances to the unbroken skin are more useful in some types of illnesses, especially in the case of dermatitis. They are also easier to use in children. Tests made by spraying solutions into the eyes or nose are very useful in confirming tests made in other ways. This is also true of inhalation tests and subcutaneous tests. It hardly seems advisable to dwell upon this large subject in detail.

FIGURE XVI—Illustrations of a pollen test in an individual who had pollen eczema. Intracutaneous tests in this case were not striking, in fact were overlooked. The tests shown in the photograph were made by applying the bulb of the weed responsible for the trouble to the patient's arm. No reaction appeared for a number of hours. The illustration represents the condition observed after a period of twenty-four hours. The large eczematous area was caused, I believe, by contact between the skin and the pollen granules deposited upon it. The small eczematous areas later fused to make a large weeping surface exactly similar to that of which the patient complained when originally observed.

## Treatment

The treatment of patients sensitive to foreign agents is often brilliant if the source of the trouble can be discovered. Avoidance of the cause is best if this can be accomplished and frequently gives rise to a brilliant rapid result. Frequently, however, the cause is difficult to avoid if it happens to be a common pollen or a common food. In this case, we have several ways of increasing tolerance for the noxious agent. It hardly comes within the scope of this article to discuss this large subject in detail. The results of this method of treatment are frequently brilliant and safe if carried out by experienced physicians.

We frequently encounter serious problems in the case of a substance found so universally in the cities as coal smoke. Individuals sensitive to coal smoke may have violent attacks in the environment of factories or railroads and can frequently relieve themselves by keeping away from such environments.

If the cause of the disorder cannot be found or, if when found, cannot be removed, we are frequently justified in giving what is known as non-specific "protein" treatment. For this purpose, peptone, typhoid bacilli, colon bacilli, milk, and other agents have been used.

## Symptomatic Remedies

*Adrenalin*—The use of symptomatic remedies is important. Adrenalin, if adequately administered, should give relief in uncomplicated cases. It is a good practice to give about one-quarter c.c. or less subcutaneously at five minute intervals until tremor appears. This usually means that an adequate administration has been given and that relief should follow. After the dose which is most useful for the patient has been discovered, it can be repeated as symptoms tend to recur. It is advisable to give adrenalin in the incipiency of an attack rather than wait until the height of the attack is reached. Adrenalin can be given repeatedly, if the dosage is correct, for months or years without much apparent ill effect.

If one wishes a more rapid effect from adrenalin in an extreme emergency, it is advisable to give it intravenously or give a given total amount, say one-half or one c.c. in five or six places intracutaneously. Both of these methods give a very quick result. The intravenous method is probably the more rapidly effective and the multiple injection probably the more useful except in extreme emergency.

*Pituitrin*—Pituitrin has an effect that is somewhat similar to adrenalin except that relief does not appear so promptly. Relief so obtained lasts longer. It is useful alone or in combination with adrenalin.

*Ephedrine*—Ephedrine, given preferably in solution, has an effect similar to that of adrenalin except that the result does not appear so promptly but lasts longer. Very frequently constitutional symptoms are disagreeable and should be avoided if possible through reducing the dose to the smallest which will give a therapeutic result. Many patients are unable to tolerate ephedrine and many do not get a good therapeutic result from it.

*Atropine*—Drugs of the atropine series are time honored remedies in the treatment of asthma. They can be given subcutaneously or by mouth. Sometimes as little as 1/200 or 1/500 grain three times a day is effective.

*Iodides*—This is a useful remedy, especially in older patients. The best dosage varies from a few drops to twenty-five or even fifty drops three times a day. Optimum dosage varies in different individuals.

*Salicylates*—Salicylates are very useful in treatment of nasal and bronchial reactions given in doses of approximately ten grains every three or four hours.

*Anesthetics*—The anesthetics, especially alcohol, are inclined to relieve asthma. Alcohol is frequently very useful, especially if combined in fair dosage with acetyl salicylate. This combination is a useful substitute for morphine in many cases.

*Habit Forming Drugs*—Habit forming drugs are absolutely contra-indicted except in emergencies which justify the chance of causing addiction. This applies especially to morphine. The hardest cases of asthma to cure are those who have become addicted to morphine.

## Sensitiveness to Physical Agents

There is a type of reaction which is very similar in history and symptomatology to the types previously described except that instead of its being caused directly by a

Figure XVII—Local Urticaria caused by scratching the skin of the patient with a glass slide. Note the fact that the oedema is confined to the area to which the irritating agent was directly applied. This area was surrounded by a much larger area of erythema. This patient was not sensitive to light and cold, nor to material substances.

material substance such as egg or pollen, it is caused specifically by sensitiveness to a physical agent such as light, heat, cold, scratches, or in case of sensitiveness to heat, by the effect of physical or mental effort. This type of sensitiveness may occur in patients who have typical allergic manifestations caused by pollen, egg, milk, or what not, or it can occur in patients in whom no sensitiveness of any sort can be found except to the physical agent itself.

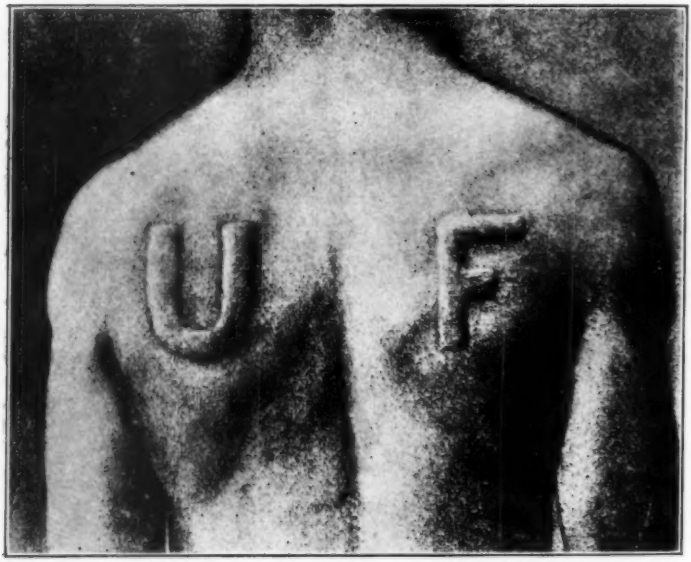


FIGURE XVIII—Urticaria caused by light. The figures shown here were caused by areas of oedema brought out by exposing skin areas to sunlight for two and one-half minutes through cardboard in which these figures were cut. Note that the oedema is confined to the areas directly exposed to light. A larger area of erythema surrounded these. The skin of the patient was not affected by scratches or by cold or material substances.

FIGURE XIX—Urticaria caused by applying ice water to the skin of the back. The oedema shown in this photograph was confined to the skin areas wet by the cold water. A larger area of erythema surrounded the oedema. The skin of this patient was not affected by scratches or by light or by material substances.

FIGURE XX—Chronic Perennial Dermatitis of many years' duration so severe as to incapacitate the patient for work, and caused by sensitiveness to heat. The skin of the patient would become relatively clear if he kept quiet and cool for several days. It would reappear several hours after exposure to heat or after a little physical or mental effort.

A number of years ago I described a group of such cases under the non-committal term Physical Allergy. Two types of reaction were noticed. One type occurred at the site of the point of contact with the physical agent. This was designated a Contact Reaction.

The other type occurred at the point of contact and in distant structures as well and frequently only in distant structures. This latter type of reaction was called a Reflex-like Reaction. This series of cases were interesting in that the manifestations were almost identical with those caused by egg sensitiveness or pollen sensitiveness.

Local or contact reactions caused by light, or scratches or cold are identical in their manifestations and behavior

and are examples of the old "factitious urticaria" except in that it can be caused by light or cold in some individuals just as it can be caused by scratches in others. The three illustrations show in one case a reaction caused by exposure of the skin to light, in another case by exposure of the skin to cold, and in another case by exposure of the skin to scratches. The reaction is characterized by redness, oedema, and itching. The oedema is confined to the point of the application of the physical agent. If in a patient of this type who is sensitive to cold, the conjunctivae and nasal membranes are chilled by the effect of cold air, typical coryza appears differing in no respect from that caused by pollen. Furthermore, if chilled air is breathed, cough and symptoms resembling asthma may appear. If a very large surface of skin is exposed in one of this type of cases, generalized symptoms resembling shock may appear. This, in two of my patients has caused complete collapse for which they were given adrenalin. If a patient is not highly sensitive and reacts slowly, the manifestation is not likely to come out as itching and hives. It may come out rather after a period of several hours in the form of eczema at the point of contact with the physical agent.

I suggested several possible theoretical mechanisms through which reactions of this sort might come about. The most romantic was based on an assumption that a patient of so-called atopic strain might become sensitive to some new body formed in the tissues under the influence of light or cold or scratches, as the case may be, and react upon application of the physical agent in the same way that a pollen sensitive case reacts upon application of pollen. Much can be said in favor of this point of view.

A second possible explanation was based upon an assumption that some individuals might become abnormal in such a way that their tissue proteins might break down under the influence of a physical agent with the liberation of a histamine like body and that the histamine like body might cause the peculiar reaction displayed by the patient.

It is a well known fact that histamine injected locally in the skin will give a hive reaction which is identical with that caused by the application of light or cold or scratches in sensitive cases. This point of view has more recently been suggested by Lewis who has by indirect evidence made the view seem more plausible.

I suggested three other possible explanations which need not be taken up in this connection.

This type of physical sensitiveness is interesting in that tolerance for the physical agent to which the patient reacts can be given by frequent exposure to the agent. For instance, light sensitive cases can be given tolerance for light by exposure to light. Scratch sensitive cases can be given tolerance for mechanical irritation of the skin by having them scratch themselves with a stiff brush at frequent intervals, and finally cold sensitive cases can be given tolerance to cold by cold baths. Tolerance can be raised to such a point that they can easily stand exposure to cold which might have caused a marked or even dangerous reaction before treatment was started. This method of increasing tolerance is useful in the treatment of dermatitis caused specifically by exposure to light or cold or scratches. It has to be carried out carefully and adequately in order to obtain a desirable result.

Whereas contact cases such as those above described are rather uncommon, reflex-like reactions are quite common. Coryza, asthma, urticaria, angioneurotic oedema, pruritis and many types of dermatitis caused by sensitiveness to heat or cold or to the combined effect of heat in one locality and cold in another, are frequently observed. Sensitiveness to heat is much more common than sensitiveness to cold.

Heat sensitiveness is characterized by reaction when the patient acquires a degree of heat which is beyond his tolerance. The source of the heat is a matter of indifference in many cases. The heat of a hot lamp or sunlight, a diathermic current, the drinking of a glass of hot water

or hot food, or heat generated by mental or physical effort may have the same effect. Some patients react most markedly to heat after exposure to cold, in which case they have symptoms in winter rather than in summer. Some acquire tolerance for heat during hot months and lose it during winter months. Cases of this type react most markedly on the first warm days of spring or summer. Many cases, however, do not become acclimated or declimated by weather changes, in which case they are inclined to react most markedly on warm humid days especially after mental or physical effort.

There is another type which reacts most markedly to heat if simultaneously exposed to cold. For example, some cases of asthma react most markedly to effort if breathing cold air. They cannot tolerate exercise while breathing winter air, but tolerate mental or physical effort during warm months. In one marked case of this sort who had asthma each night, symptomatic relief was obtained through such a simple procedure as sleeping in a warm room with little cover.

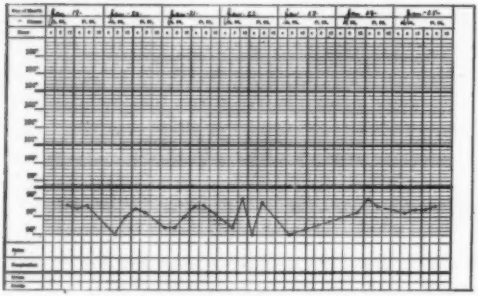
Symptoms of heat sensitiveness may be classified as:

First: General or constitutional reactions.

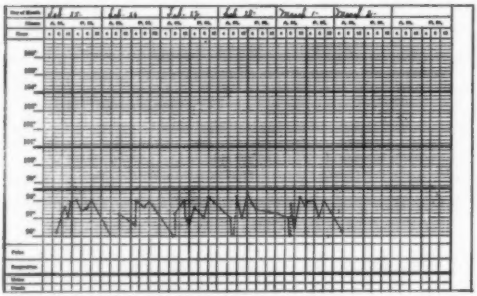
Second: Symptoms referable to a given organ.

Third: Symptoms referable to one of the three cooling surfaces, that is the skin, the nasal membranes, and the bronchial mucous membrane.

Symptoms vary in different individuals in intensity, in the quickness with which they appear, and in location. In some patients the symptoms are chiefly constitutional. Classical illustrations of this are heat prostration and the effort syndrome. In classical cases of Lewis' effort syndrome, typical symptoms can be elicited frequently by warming the patient up with a hot lamp, or by immersing the hands and fore-arms in a water bath at 42 degrees centigrade. The attacks can be prevented or stopped by the simultaneous application of cold. Symptoms caused



XXI



XXII

FIGURE XXI-XXII—Typical temperature charts ot heat and cold sensitive cases. The charts are characterized by their being almost constantly subnormal, irregular, and unstable. The frequent ups and downs so commonly observed in charts of this type are due to exposure to heat or cold or to the effect of the heat produced by exercise. The frequent marked rises shown by the dotted line in Figure XXII were brought out by a little exercise followed by a cold bath.

by effort syndrome can often be stopped by the rubbing of the hands and arms with ice. In the majority of cases which I have tested symptoms may be elicited by immersing the hands and fore-arms in water at 42 degrees centigrade even if tourniquets are applied above the elbows so tightly that blood can neither enter nor return from the arm. Evidently, the clinical manifestations in this type of case originates in an increase in the sensation of heat.

Symptoms referable to the cooling surfaces are practically identical to those caused by sensitiveness to pollen or egg, namely, coryza, bronchial asthma, pruritis, urticaria, or dermatitis, etc. They likewise can be reproduced by the suitable application of heat and can be relieved by the adequate application of cold. A typical example of this type of reaction is that of a patient who had a summer dermatitis of the face which was so severe as to keep her from appearing in public places during the summer months. I saw her in the winter and reproduced the dermatitis through immersing her hands and fore-arms in a water bath at 42 degrees centigrade for one minute, even with tourniquets tied so tightly above the elbows that blood could neither enter or return from the arm. The dermatitis could be as quickly relieved by the application of ice to the fore-arms and hands even before the removal of the tourniquets. Removal of the tourniquets made little difference in the skin manifestations on the face.

Cold sensitiveness may be exactly similar to the above except that the reactions are caused by cold instead of by heat. Symptoms in a cold sensitive case can be relieved by a hot lamp, by immersing the hands and fore-arms in a water bath of 42 degrees centigrade or by the heat produced by mental or physical effort. I had one case of asthma caused by cold sensitiveness which was once temporarily relieved by a physical encounter.

Whereas, heat sensitive cases instinctively seek a quiet life, cold sensitive cases seek a life of activity. It is

unfortunate for the patient if the career and environment which he has instinctively chosen is changed to the reverse. Many heat sensitive cases who instinctively led a sedentary life were drafted during the war, and caused to make an effort which was beyond their tolerance. They suffered from symptoms such as effort syndrome, heat prostration, coryza, asthma, dermatitis, or urticaria. Cold sensitive cases may be equally unfortunate if they are taken from a life of effort and caused to lead a sedentary life. This may be illustrated by one of my patients who was brought from a life of activity to one of inactivity through the prolonged illness of her husband. At the time I saw her, she was the more ill of the two, and was relieved when she resumed her previous life of effort.

The recognition of the above types of illnesses is very important both for the patient and for the physician. One is limited in his methods of treatment in heat sensitive cases, but can frequently give advice concerning habits and activity, which are useful. Cold sensitive cases often gain such tolerance for cold through the effect of cold baths, that they can frequently live in comfort. Heat sensitive cases acquire tolerance with difficulty or not at all. Severe cases are unfortunate. Mild cases can often readjust their lives and habits so that they can live in comfort.

Dry air is better for either class of case than humid air--in fact, for highly sensitive cases, prolonged exposure to humid air may actually menace life and health. The heat regulating mechanism can function more easily in dry than in moist air because of the cooling effect of evaporation by dry air and its lessened conductivity for heat.

Both heat and cold sensitive cases are unduly susceptible to infection in the bronchial and nasal mucous membranes after exposure to variation in temperature which would be a matter of indifference to a normal person. In the cases who live in changeable climates, we often find a history of frequent attacks of coryza or pneumonia.

It is impossible to discuss adequately such a complicated problem in the short time at my disposal. I hope, however, that I may interest the readers in the further study of the condition. It is definite, relatively common and causes much trouble.

Heat and cold sensitiveness of this class is due, I believe, to a disorder in the heat regulating mechanism. The disorder in the heat regulating apparatus is caused commonly, I believe, by an acute febrile disease. In this case nothing can be found on examination except an almost constantly subnormal temperature, hypotension, subacidity or achylia and sensitiveness to the effect of heat or cold. In many so-called secondary cases, it is caused, I believe, by some local or general disease which impairs the normal action of the heat regulating mechanism and hampers its effort to maintain temperature at levels which are ideal for body function.

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NOVEMBER 1ST.

*Interpretation of kidney function in clinical practice.*

Dr. Herman O. Mosenthal, Professor of Medicine, New York Post-Graduate Medical School and Hospital.

Kidney function in its physiological interpretation according to modern researches—these physiological principles applied to clinical tests —the value of tests of renal function interpreted in this manner in clinical medicine.

NOVEMBER 8TH.

*Parasitology from the clinical standpoint.*

Dr. Francis W. O'Connor, Associate Professor of Medicine, Columbia University.

Animal parasites known to cause disease in temperate climates. Parasites affecting emigrants from warm climates, symptoms occurring amongst such persons indicating careful examination for parasites. The influence of some parasites in preventing or retarding convalescence after other disease conditions.

NOVEMBER 15TH.

*Present day treatment of syphilis with a consideration of the comparative value of remedies employed.*

Dr. Jay F. Schamberg, Professor of Dermatology and Syphilology, Graduate School of Medicine, University of Pennsylvania.

Discussion of the value of arsphenamin, neoarsphenamin, sulpharsphenamin, bismuth, mercury and the iodides in the treatment of syphilis. Remarks upon the laboratory and clinical evidence bearing

upon the relative importance of each medicant. Outline of the treatment of syphilis in the primary and secondary stages, in latent syphilis, in visceral syphilis, in congenital syphilis, and in neurosyphilis. Discussion of malaria and other fever inducing agencies in the treatment of neurosyphilis. Brief reference to foreign protein injections and hygienic measures to increase the native resisting power.

NOVEMBER 22ND.

*The relation of orthopedics to pediatrics.*

Dr. Frank R. Ober, Instructor in Orthopedic Surgery, Harvard University.

A discussion of the value of co-operation between the pediatrician and the orthopedic surgeon. A consideration of the diagnostic points of border-line cases, such as poliomyelitis, acute articular rheumatism, rickets and allied conditions, and tuberculosis of joints. The relation of foot strain, posture, etc., to the undernourished child. Finally, some attention will be paid to therapeutic measures in several of the diseases which belong both to the pediatrician and to the orthopedic surgeon.

DECEMBER 6TH.

*The psychic factor in cardiac disorders.*

Dr. Lewis A. Conner, Professor of Medicine, Cornell University Medical College.

Doubt concerning the integrity of the heart excites a much more violent psychic reaction than is the case with disturbances of other organs. Frequency and importance of cardiac neuroses. The psychic factor in organic heart disease. Value of reassurance and encouragement in the treatment of cardiac disorders.

DECEMBER 13TH.

*Acidosis and the water exchange.*

Dr. John P. Peters, Professor of Medicine, Yale University.

Consideration of the nature of acidosis and its relation to changes in the water and salt content of the body and the bearing of these factors on the treatment of disease conditions.

DECEMBER 20TH.

*Inheritance as a factor in disease.*

Dr. Raymond Pearl, Professor of Biology, Johns Hopkins University.

1930

JANUARY 10TH.

*The cancer problem in its various phases.*

Dr. Joseph Colt Bloodgood, Clinical Professor of Surgery, Johns Hopkins University.

Cancer as a world problem, as a public health problem, as a problem of the medical, dental and nursing professions, of the expectant mother and the mother of children, as an individual personal health problem, as a research problem.

JANUARY 17TH.

*The failing heart of middle life.*

Dr. David Riesman, Professor of Clinical Medicine, University of Pennsylvania.

There is a marked increase in deaths from diseases of the heart. This increase affects especially the middle and later periods of life. The causes and nature of this type of heart disease, its early recognition, and its treatment.

JANUARY 24TH.

*The eye in relation to general medicine.*

Dr. Edgar S. Thomson, Surgeon, Manhattan Eye, Ear and Throat Hospital.

Eye headaches (their character), muscle disturbances, significance of conjunctival and corneal diseases, causes of iritis and cyclitis, choroiditis, retinis, vascular changes, (hemorrhage). Optic nerve, neuritis, choked disc, functional changes, hysteria.

FEBRUARY 7TH.

*The diagnosis and treatment of meningococcus meningitis.*

Dr. Stafford McLean, Assistant Clinical Professor, Diseases of Children, Columbia University. Attending Physician, Babies' Hospital.

The clinical manifestations of meningeal irritation, the indications for diagnostic lumbar puncture, the methods and routes in serum therapy, results.

FEBRUARY 14TH.

*The premarital examination and conjugal adjustments.*

Dr. Robert L. Dickinson, Senior Gynecologist and Obstetrician, Brooklyn Hospital.

New data from 1000 marriages with follow-up. Varying sexual factors in successful marriage. Preventive methods of minimizing frigidity, dyspareunia, abortion and sterility.

FEBRUARY 21ST.

*Psychiatry's part in preventive medicine.*

Dr. Arthur H. Ruggles, Chief Neuro-Psychiatrist, Butler Hospital, Providence.

Previous to fifteen years ago, psychiatry was largely concerned in the classification and custodial care of mental disease. Since that time much progress has been made in the understanding and treatment of such diseases as general paresis, in a better understanding of schizophrenia and of the manic-depressive psychoses. Psychiatric examinations in the schools have done much in the way of prevention, and in the child guidance clinics a valuable piece of work in prevention and research is being accomplished. Industry is studying the personality factors in its workers, and mental hygiene has become a part of the health departments of many of our colleges.

FEBRUARY 28TH.

*Specific hypersensitiveness as a cause of symptoms in disease.*

Dr. Arthur F. Coca, Serologist, New York Hospital, Professor of Immunology, Cornell University.

Pathology and symptomatology of anaphylaxis in lower animals; idea of specific mechanism and shock tissue in specific hypersensitiveness. The shock tissue and shock organs in atopic human hypersensitiveness; influence of heredity. Non-atopic forms of human hypersensitiveness. (Specific dermatitis; hypersensitiveness of infection.)

MARCH 7TH.

*The treatment of nephritis.*

Dr. Rolfe Floyd, Physician, Roosevelt Hospital.

Treatment of the inflammation of the renal tissue. Treatment of dropsy and allied conditions. Treatment of uraemia. Treatment of hypertension and its results.

MARCH 14TH.

*The diagnosis and treatment of cerebral neoplasms.*

Dr. Charles A. Elsberg, Professor of Neurological Surgery, Columbia University.

The symptoms that should make the general practitioner suspect a brain tumor. The diseases with which tumors of the brain may be

confused. The time when the diagnosis can be made and when the patient should be referred for surgical treatment. The surgical treatment of brain tumors, and the results that can be obtained.

MARCH 21ST.

*Can our methods of obstetric practice be improved?*

Dr. Benjamin P. Watson, Professor of Obstetrics and Gynecology, Columbia University.

A short survey of methods of obstetric practice in different countries. Contrast between hospital and domestic practice. Can the latter be made to conform more closely to the former? Would the trained midwife or obstetric nurse be a help or a hindrance?

MARCH 28TH.

*The treatment of general infections of the bloodstream.*

Dr. Alphonse R. Dochez, Professor of Medicine, Columbia University.

Consideration of the conditions under which bacterial invasion of the blood takes place. The practical difference between so-called bacteremia and septecemia. The use of chemical agents for sterilization of the blood. The use of biological agents for sterilization of the blood. The importance of local foci of infection in the continuance of septecemia.

APRIL 4TH.

*Diseases of the arteries of the extremities and their treatment.*

Dr. Leo Buerger, Attending Surgeon, Bronx Hospital.

Importance of the recognition and differentiation of the inflammatory thrombotic and degenerative types of occlusive diseases of the arteries from a pathological standpoint. Importance of the segregation of the entity thrombo-angiitis-obliterans from what the lecturer regards as angio thromboses. Discussion of treatment of arterial diseases per se. Methods of treatment directed towards the impaired circulation resulting from occlusive changes in the arteries and veins.

APRIL 11TH.

*Drug addiction.*

Dr. Alexander Lambert, Professor of Clinical Medicine, Cornell University.

Drug addiction. Psychologic causes of all narcotic addiction. Some misconceptions regarding drug addicts. Comparative discussion of various treatments. Management and prognosis of individual drug addicts.

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## FELLOW AND HONORARY FELLOW ELECTED OCTOBER 3, 1929

Livingston Farrand, M.D., LL.D., President of Cornell University, Ithaca, New York.

John Toole.....30 East 40th Street

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## DEATHS OF FELLOWS OF THE ACADEMY

Samuel Feldstein, M.D., 50 Plaza Street, Brooklyn, New York; graduated in medicine from the Harvard Medical School, Boston, Massachusetts, in 1902; elected a Fellow of the Academy, December 3, 1908; died, September 14, 1929. Dr. Feldstein was a Fellow of the American Medical Association and a member of the County and State Medical Societies. He was a member of the Society of Associated Alumni of Mt. Sinai Hospital, a member of the Pathological Society and the Pediatric Society, Pediatrician to the Jewish Hospital of Brooklyn and Consulting Physician to Kingston Avenue Hospital, Brooklyn.

Irwin Howell Hance, M.D., Lakewood, New Jersey; graduated in medicine from the College of Physicians and Surgeons, New York City, in 1883; elected a Fellow of the Academy, February 3, 1887; died September 28, 1929.